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RESEARCH AND DEVELOPMENT INSTITUTES IN DEVELOPING COUNTRIES AND THEIR CONTRIBUTION TO TECHNOLOGICAL INNOVATION

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A synthesis report prepared by the UNCTAD secretariat

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FOREWORD

(i) In section V, paragraphs 15 and 16, of resolution 28 (V), the Committee on Transfer of Technology requested the UNCTAD secretariat, in co-operation with other institutions concerned, to "continue its valuable studies of policies and instruments on the promotion and encouragement of technological innovation in all countries, and particularly in developing countries, taking into account the comments and views expressed at the fifth session of the Committee". According to the same resolution, the secretariat's studies should, *inter alia*, consider the influence the following factors may have in promoting and creating an innovative environment:

(a) Risk-taking in a changing, innovative environment;

(b) Incentives required at all levels of society, including those provided by system of industrial property protection; and,

(c) Linkages, including feedback mechanisms, between research and development activities reflecting practical local endowments and conditions.

(ii) The present synthesis report has been prepared in response to subparagraph (c) above. It incorporates three country case studies undertaken by the secretariat to assess the role of R and D institutes in contributing to technological innovation in developing countries. The three countries are: Indonesia, Senegal and Sri Lanka.

(iii) Given the lack of systematic work on technological change and the little progress in understanding technological innovation in developing countries the present report is exploratory in nature. R and D institutes represent only one amongst many possible sources of technological innovation. An assessment of their role is important for two reasons. First, it can lead to some constructive suggestions on how to improve their contribution to technological innovation. Secondly, it can be viewed as a point of departure for a more comprehensive inquiry into technological innovation in developing countries.

(iv) The important role of scientific and technological capabilities for technological and economic development has led to the establishment of public research institutes in developing countries. Most of the institutes have been established from the 1950s onwards, often with the technical and financial assistance of international agencies.

(v) The principal aim of public R and D institutes of both, multi-purpose institutes (servicing different industries) and single-purpose institutes (servicing one particular industry) has been the improvement of existing industries through the development of new products and processes, the increased utilization of indigenous materials, the adaptation of imported technology and the provision of technical services and training of industry personnel.

(vi) There has been a growing concern that the performance of R and D institutes lags behind expectations. On the one hand, the overall output efficiency is unsatisfactory compared to the allocated financial and human resources. On the other hand, even in the cases where the R and D institutes have succeeded in building up specialized technological capabilities or where they have produced improved or new products and processes, they have had little impact on the productive sectors because many of the R and D results have not been used industrially.

(vii) The insufficient use of R and D results may be due to many reasons. In a very general way, it can be attributed to the insufficient linkages between R and D institutes and the productive sectors. The linkage problem may arise in several ways. Firstly, there may be an information gap about the institutes' results. The potential users are not aware of the institutes' activities or have no confidence in their work. Secondly, there may be a lack of supporting services and mechanisms that ensure and facilitate the commercialization of R and D results. Thirdly, and probably most importantly, R and D outputs often do not conform with the actual requirements of the potential users.

(viii) The insufficient demand orientation may have different reasons. For example, during the design phase of a new output the industry's requirements are not taken sufficiently into account, or there is a lack of feed-back mechanisms during the implementation phase and there are insufficient provisions for its industrial application. Empirical information in this area is severely lacking. The UNCTAD secretariat's work is therefore attempting to focus on these aspects.

(ix) The present synthesis report is based on three country studies. Publicly-financed R and D institutes, performing R and D functions mainly in the agro-food industry and metal-working industry were analysed. Emphasis has been given to these two industries has been given because they are generally regarded as having a critical importance for development in their respective countries. The method of gathering information was through interviews and questionnaires. To the extent possible, the information has been standardized in order to make comparisons possible.

(x) The Indonesian case study covered five research institutes, and two university institutes, all of which are mainly oriented towards the capital goods sector. In Sri Lanka, five research institutes were analysed which service the chemical, the capital goods, and the agro-food industries. In Senegal, two institutes within the agro-industry have been covered.

(xi) In preparing the present synthesis report a uniform concept of technological innovation was adopted. For this purpose a clear distinction between the different functional activities of R and D institutes was useful: basic R and D activities, industrial services and training. Each of these activities was then assessed within the framework of the R and D institutes' innovation chain: idea generation and project design, building up of capabilities and technical solution and industrial application of the R and D output.

(xii) The UNCTAD secretariat is grateful to the Government of Sweden for financial support given for this work through the Swedish Agency for Research Co-operation with Developing Countries (SAREC).

Chapter I

OVERVIEW OF THE SELECTED R AND D INSTITUTES

A. General

1. This report presents the findings of three country case studies undertaken by the secretariat to assess the role of R and D institutes (RDIs) in contributing to technological innovation. The three countries are : Indonesia, Senegal and Sri Lanka.[1] In combining the three case studies an attempt is made to gain a more general understanding on the role of RDIs in developing countries.

2. Generalizations from individual RDIs' observations appear justified because of the RDIs' common objectives and historical coincidences. Thus, most of the RDIs have been established from the 1950s onwards, often with the technical and financial assistance of international agencies in recognition of the important role of scientific and technological capacities for economic development. In the absence of research activities in the productive industries, publicly funded RDIs have been regarded as crucial to spur technological development and they have become an important element of the technical infrastructure of many developing countries.

3. Nevertheless, different historical development paths and development prospects of individual countries, as well as corresponding divergences in industrial specialization, render cross-country and cross-industry comparisons difficult. These differences need to be taken into account when the findings of individual RDIs are compared and generalizations need to be treated with caution.

4. The three countries surveyed vary considerably regarding their levels of technological development and degrees of industrial specialization. The latter is of particular importance since it determines the technological needs and the areas of specialization of publicly funded RDIs. Accordingly, the selection of the institutes in the three countries has been guided by the economic and strategic importance of the corresponding industries. In Indonesia, five RDIs have been analyzed which serve the capital goods industry. For Senegal, two RDIs within the agro-industry were covered and in Sri Lanka, five RDIs, serving the chemical, the capital goods and the agro-food industry were assessed.

5. One way of showing the different scientific and technological development levels of the three sampled countries is by comparing their scientific and technical manpower (see table 1). These numbers mirror the countries' different potentials for horizontal diversification in different disciplines of science and technology as well as their possibilities for vertical specialization by building up specific scientific capabilities. As expected, Indonesia has by far the largest stock of scientists and engineers and scientific and technical personnel in R and D. More important than absolute numbers of scientific personnel is their intensity with respect to the population. Accordingly, Indonesias' intensity of scientific personnel per 10.000 inhabitants is about ten times higher than in Sri Lanka, which in turn is about seven times higher than in Senegal.

6. At the same time Senegal's share of scientific manpower which is engaged in formal R and D is with over 40 per cent by far the highest. The lower corresponding shares of Sri Lanka (15.1 per cent) and Indonesia (1.4 per cent) indicate that the majority of the scientific personnel is not primarily engaged in formal R and D. Although it would be difficult to establish a cause-and-effect relationship on the basis of the above figures it would appear that the concentration of scientific personnel in formal R and D is inversely related to the overall level of technological development. One possible explanation is that in countries where the total number of scientists and engineers is small, institutionalized R and D plays a relatively more important role due to the weak industrial base.

7. The following brief description of the surveyed RDIs in Indonesia, Senegal and Sri Lanka provides an overview of their historical background, area of specialization and their scientific personnel.

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[1] The case studies on Senegal (UNCTAD TT 93) and Sri Lanka (UNCTAD TT 95) were published.

Table 1

Scientific and technical manpower

Country	Estimated stock of potential scientists, engineers and technicians		Scientists and engineers in research and experimental development		(3) as % of (1)
	Number (1)	Per 10,000 inhabitants (2)	Number (3)	Per 10,000 inhabitants (4)	(5)
Indonesia	2,104,780	144	29,621	1.8	1.4
Sri Lanka	18,454	14	2,790	1.8	15.1
Senegal	1,200	2	522	0.9	43.5

Source: UNCTAD secretariat based on (i) UNESCO, *Statistical Yearbook 1988*, tables 5.3 and 5.4 for Indonesia and Sri Lanka; and (ii) field interviews for Senegal. The data for the two variables are not necessarily for the identical year and are subject to many qualifications.

B. Indonesia

8. Indonesia's R and D sector consists of three categories of institutes: (a) departmental R and D institutes, which operate under a particular ministry and deal with sectoral concerns, (b) non-departemental R and D institutes, which are relatively autonomous along the lines of scientific disciplines in collaboration of the Indonesian Institute of Sciences and of the Ministry of Research and Technology with the aim to strength basic and applied research; and (c) university related institutes. (See table 2).

9. Indonesia's determination to accelerate the development of the capital goods sector has led to a number of measures relating to the establishment and reorganization of institutional set-ups. Research establishments have been united under the Ministry of Science and Technology. Contrary to the former distinction between 'academic' and 'ministry-affiliated-bureaucratic' research, the R and D institutes have been redesigned in an attempt to meet the technological needs of the industry. The importance of R and D institutes in the development of the capital goods sector is closely linked with the ambitious investments in technologically complex industries. The central role of R and D institutes in promoting technological advance is further underlined by the limited R and D activities of the enterprise sector. Five R and D institutes were examined in depth.

10. The Metal Industries Development Centre (MIDC), the Institute for R and D of Industrial Materials and Technological standards (B4T), the National Institute for Electronics Technology (LEN), the R and D Centre for Calibration, Instrumentation and Metrology (LKIM) and the strength of Materials, Components and Structures Laboratory. An overview of these institutes in terms of historical background, institutional objective and targeted industries is shown in table 3.

Table 2

Indonesian R and D organizations studied

Type and name of R and D institutes	Supervising authority
I. Departmental R and D institutes	
1. Metal Industries Development Center (MIDC)	Ministry of Industry
2. Institute for R and D of Materials and Technical Standards (B4T)	Ministry of Industry
3. Institute for R and D of Textile Industry	Ministry of Industry
II. Non-departmental R and D institutes	
1. National Institute for Electronics Technology (LEN)	Indonesian Institute of Sciences (IIS)
2. National Centre for Research, Science and Technology (PUSPITEK)	Ministry of Research and Technology
a. R and D Centre for Calibration, Instrumentation and Metrology (LKIM)	IIS
b. Strength of Materials, Components and Structures Laboratory (LUK)	Agency for the Assessment and Application of Technology (BPPT)
c. Aerodynamics, Gasdynamics, and Vibration Laboratory (LAGG)	BPPT
d. Energy and Energy Resources Laboratory (LSDE)	BPPT
III. University	
1. Bandung Institute of Technology (ITB)	Ministry of Education
2. Surabaya Institute of Technology (ITS)	Ministry of Education

Source: UNCTAD secretariat, based on information provided by the Ministry of Industry.

Table 3

Profile of Indonesian R and D institutes studied in-depth

	Metal Industries Development Centre (MIDC)	Institute for R and D of Industrial Materials and Technological Standards (B4T)	National Institute for Electronics Technology (LEN)	R and D Centre for Caliberation Instrumentation, and Metrology (LKIM)	Strength of Materials Components and Structures Laboratory (LUK)
Year of Establishment	1969	1909	1965	1967	1981
Historical background	Developed with Belgian ODA co-operation in 4 stages over 1970-1987;	Established by the Dutch Government as metal testing laboratory; reorganized in 1986	Initiated as a research project in 1962; became a national institute in 1965; reorganized in 1986	Established as a LIPI institute; since 1983 moved into PUSPITEK	Established as part of new PUSPITEK R and D complex
Stated objectives	To carry out development work on product and production technology for metals and machinery industry; emphasis on quality improvement	To carry out R and D testing services on materials, production processes and products; emphasis on quality assurance	To carry out basic and applied R and D to facilitate transfer of latest electronics technology from abroad	To carry out R and D for development of equipment, methods and appropriate practice in support of instrument industries	To carry out testing and research on structures and components made of metal, concrete, etc. for various industries
Target industries	Metal and machinery	Metal and machinery	Manufacturing-good	Instrumentation	Manufacturing-good
Financing	Fees and public funds	Fees and public funds	Fees and public funds		Fees and public funds
Scientific personnel	238, including: - Graduate engineers: 23 - Tech. academy graduates: 31	226, including: - Graduate engineers: 32 - Tech. academy graduates: 29	1,500, including: - Graduate engineers: 150 (Incl. 11 Ph.Ds and 30 MSs)	307, including : - Graduate engineers: 80 (23 pursuing good work abroad)	143, including: - Graduate engineers: 45 - Tech. academy graduates: 13

Source: Information obtained from the institutes.

C. Senegal

11. The establishment of Senegal's research infrastructure was initiated in the 1960s and 1970s. The emphasis on institutional, public R and D was regarded as necessary to spur technological advance since there was hardly any research carried out at the firm level. Senegal's research infrastructure is still at an early stage of development and depends on external assistance. About half of the total stock of researchers are not Senegalese nationals and external finance accounts for over 50 per cent of many of the research institutes' budgets.

12. Research activities in Senegal are to a large extent related to the agro-industry. More than 450 of the total of 1200 researchers deal with agro-industry research. Most of the research activities are located around the university, which employes over 400 researchers. Among the research institutes, which are not attached to the university, the Institute for Agriculture Research (ISRA) with 420 researchers is by far the biggest. ISRA, established in 1974, is involved in a variety of agricultural research activities, including seed improvements and food-processing.[2] Besides the ISRA, the Institute de Technologie Alimentaire (ITA) is exclusively concerned with research in the agro-industry. The Ecole Nationale Supérieure Universitaire de Technologie (ENSUT) plays a supplementary role with emphasis on education and training. It is the latter two institutes which are analysed in depth. An overview of the two institutes is given in table 4.

D. Sri Lanka

13. In Sri Lanka several RDI's were established during the early post-independence period with emphasis on the industrial sector. The public sector accounts for over 90 per cent of total R and D expenditure whose total share in GDP is about 0.2 per cent. In terms of total R and D expenditure by industry, the agriculture absorbs the largest share, accounting for about 60 per cent. In Sri Lanka there are presently about 80 R and D institutes which carry out R and D activities on a regular basis.

14. The four RDIs selected for the purpose of this pilot study comprise some of the most important institutes in Sri Lanka. They account for over 40 per cent of the total national R and D expenditures and employ a large share of all engineers in the country. Two of the selected RDIs are related to the industrial and two to the agricultural sector. The two RDIs in the industrial sector are the Ceylon Institute of Science and Industrial Research (CISIR) and the National Engineering and Development Centre (NERD). Both institutes are operating under the Ministry of Industry and serve different industries. CISIR, which employs over 170 researchers is mainly related to the agro-food and chemical industry while NERD, with about 50 researchers, focuses mainly on the metal-working and machine-building industries. The two selected RDIs in the agricultural sector are the Tea Research Institute (TRI), the Rice Processing R and D Centre (RPRDC). Both single-purpose institutes deal with the improvement, culture, harvesting and processing of agro-products. An overview of the four selected institutes is given in table 5.

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[2] The ISRA was subject of the UNCTAD study entitled, "The food industry in Senegal, with particular reference to the processing of grains, fisheries products and milk products" (UNCTAD TT 71), 1986.

Table 4

Profile of surveyed R and D insitutes in Senegal

Description	Institut de Technologie Alimentaire (ITA)	Ecole Nationale Supérieure Universitaire de Technologie (ENSUT)
Year of establishment	1963	1965
Historical background	Since 1968 assistance from the UN Food and Agricultural Organization (FAO); reorganized 1985	Attached to the University;
Target industries	Agro-food	Agro-food
Stated objectives	To carry out research on food-product development, treatment, processing, packaging, preservation of raw materials and food products; to provide training.	Provision of education facilities and training; research on utilization of raw materials.
Scientific personnel	100, including: Researchers, Managers: 35 Senior technicians: 20 Technicians: 20	100 teachers out of which approximately 75 are engaged in research activities
Financing	Technical assistance and public funds	Technical assistance and public funds

Source: Information obtained from the institutes.

Table 5

Profile of the selected R and D institutes in Sri Lanka

Description	Cylon Institute of Science and Industrial Research (CISIR)	National Engineering and Development Center (NERD)	Tea Research Institute (TRI)	Rice Processing R and D Centre (RPRDC)
Year of establishment	1955	1974	1925	1976
Historical background Parent ministry	Under the Ministry of Industries; oldest R and D institute in the industrial sector	Under the Ministry of Industries; became operational in 1978	Since 1976 under the Central Tea Board	Assistance from FAO/UNDP during establishment: under the Ministry of Agriculture
Target industries	Chemical industry and agro-food industry	Various industries	Tea plantation and processing	Rice plantation and processing
Stated objectives	Development of products and processes with emphasis on analysis of local raw materials; provision of training; engage in technology transfer	Development of products and processes with emphasis on engineering design, renewable energy, transport technologies, electronics and electric engineering	R and D activities in all matters relating to culture and processing of tea; dissemenation of information	Product development and quality improvement; all aspects of rice culture, processing
Financing	Public funds	Public funds	Public funds, linked with tea exports	Public funds
Scientific personnel	170, including: Natural Scientists: 57 Engineers: 10 Technicians: 103	47, including: Natural Scientists: 0 Engineers: 27 Technicians: 20	130, including: Natural Scientists: 47 Engineers: 0 Technicians: 83	11, including: Natural Scientists: 4 Engineers: 2 Technicians: 5

Source: Information obtained from the institutes.

Chapter II

ASSESSMENT OF THE R AND D INSTITUTES SURVEYED

A. The methodological approach

15. It is often argued that the overall performance of RDIs in developing countries is unsatisfactory.[3] Contrary to conventional methods of focusing on organizational matters and factors which constitute the institutional environment,[4] the pilot studies attempted to assess the performance of the institutes at each phase in the process of technological innovation with emphasis on the application of R and D results.

16. For the purpose of the study, technological innovation is defined in a broad sense to include any technological novelty or invention, which is new to the domestic industry and which finds commercial application. For the purpose of the pilot studies, the R and D activities which lead to technological innovation are classified in three subsequent phases:[5]

(i) Idea generation and project selection;

(ii) Problem solving and technical solution or output generation;

(iii) Implementation, commercialization and diffusion.

17. In the case of adoptive innovation i.e. -- the innovation which results from efforts to appropriate imported technology -- the sequence and the composition of the phases differ in so far as the assimilation and the adaptation of the imported technology takes place mainly within the firm's environment. In such cases the function of RDIs is to develop specialized skills and knowledge to provide assistance in accomplishing a successful adaptation, which usually involves minor and major technological changes.[6]

18. In the above framework, the focus of the pilot studies was on the first and last phase of the innovation process. Regarding the idea generation and project formulation phase, one may distinguish between two extremes: in-house generated activities and activities which result from industry requests. The subsequent stage, the output generation or the building up of service capabilities reflects the institutes' internal performance. The last phase of the innovation process, the implementation and diffusion, is of particular interest for this pilot study and factors that hinder or foster it are analysed in more detail.

19. Finally, it is necessary to take into account the different functions of RDIs in order to allow for a more differentiated assessment of their contribution to technological innovation. According to UNIDO,[7] the RDIs' functional activities can be divided into tree broad categories:

(i) R and D activities leading to new or improved products and processes;

(ii) The build-up of specialized capabilities which enable the provision of technical services such as chemical analysis, material testing, techno-economic studies etc.; and,

(iii) The provision of training and dissemination of information.

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[3] See e.g. D. Crane (1977) "Technological innovation in developing countries: a review of the literature", *Research Policy*, vol. 6, No. 4; F. Stewart (1984) "Facilitating indigenous technical change in Third World countries" in *Technological Capability in the Third World*, M. Fransman and K. King (eds) New York: St. Martin's Press; F. Ranis (1978) "Science, technology, and development: a retrospective view" in *Science, Technology, and Development: A Historical and Comparative Study*, W. Beranek Jr. and G. Ranis (eds) New York: Praeger.

[4] See, for example, UNIDO UNDP (1976) or D.N. Bengston "Exogenous factors affecting research institutions in developing countries", *Technology Management*, vol. 4, No. 3, 1989.

[5] For methodological aspects of categorizing innovation phases in RDIs, see J. Lee, A. Rubenstein, "An analysis of factors influencing the utilization of contract research in Korea", *Research Policy*, vol. 9 (1980).

[6] See D. Leonardo, "Implementation as mutual adaptation of technology and organisation", *Research Policy*, 17, 1988.

[7] UNIDO, *Industrial Research Institutes* (UNIDO ISD.119 Rev.1), 1975.

20. Among the above functional activities only the first qualifies as leading to technological innovation. Technical services, training and dissemination of information do not lead by themselves to improved products or processes. The provision of training and dissemination of information can be viewed as an input to strengthen overall technological capabilities and to create an awareness of opportunities. The provision of more or less standardized technical services is generally geared to improving processes and products. However, whether these improvements are technical novelties is an ambiguous and difficult question to answer. It may be assumed that a large share of technical services does not expand domestic knowledge frontiers but rather aims at overcoming basic industrial bottlenecks. However, the provision of such services may have an important impact on economic performance, and it has therefore, together with the training function of RDIs, been included in the pilot studies.

21. Based on above methodological clarifications regarding phases of the innovation process and functional activities of RDIs, the following sections provide an overview of the findings of the pilot studies. R and D activities are discussed separately from industrial services and training since they differ considerably in the way they are designed, built up and applied. Given the objective of the pilot studies to assess RDIs' contribution to technological innovation the emphasis is on R and D activities which are discussed below in accordance with the three phases of innovation. In addition, factors underlying the commercial application of R and D outputs are analysed on the basis of firm interviews of the corresponding industries.

B. Idea generation and project selection by the R and D institutes

22. The way R and D activities are designed and the criteria applied for their selection may have important implications for the relevance and commercial viability of the subsequent research results. In general, one may assume that a close interaction between the R and D institutes and the potential users is helpful in all phases of the innovation process. It ensures that the actual requirements are taken into account in the design phase. Simultaneously it helps to build up a mutual relationship which facilitates the later application of R and D results.

23. One may distinguish between user-demanded R and D activities, like for example contractual research, and in-house generated R and D activities. Concerning in-house conceived R and D activities major impulses may stem on the one hand from parent ministries, research councils and research officers and on the other from user requirements as identified through market surveys or general requests.

24. Regarding the surveyed RDIs in Indonesia, it was found that a substantial share of the R and D activities were in-house generated. The selection and design of R and D projects, which were not directly user-demanded, were based on (i) instructions from the parent ministry (MIDC), (ii) monitoring and evaluating foreign technological developments (LEN), or (iii) surveys and studies on domestic industrial technological requirements (LKIM and ITB). Industry requested R and D work played a small role for the MIDC, although it has gained importance in conjunction with budgetary adjustments. For the remaining Indonesian R and D institutes, user-requested R and D activities were of greater importance.

25. For the Sri Lankan institutes surveyed which serve the industrial sector, (CISIR and NERD) it was found that around 80 per cent of all R and D projects were initiated in-house. For both institutes, scientific boards, research planning councils or governing boards were involved in the long term development plans. Externally demanded R and D projects were carried out under research contracts. However, most of the external requests were related to technical services rather than product or process development activities. A similar relationship between externally demanded and internally initiated R and D activities prevailed in the agricultural R and D institutes. In the case of the TRI all projects were in-house initiated, based to a large extent on policy recommendations and research priorities adopted by the parent ministry. The actual research projects were mostly designed by research officers, taking into consideration the research priorities and feedbacks from the potential clients via a well-established extension service. In the case of the RPRDC around 50 per cent of the R and D projects were said to result from client's requests. Regarding the in-house initiated projects the selection criteria were derived from specific research policy objectives.

26. The two surveyed R and D institutes in Senegal differ from the Indonesian and Sri Lanka institutes as regards project selection in so far as foreign donors, which finance large portions of the R and D institutes' budget, influence the selection of R and D projects. This type of R and D project selection is frequently used by ITA and to a lesser extent by ENSUT. Projects, which are financed from national sources are selected in concordance with macro-economic, long-term developmenmt plans. In both cases of project selection, local industries are hardly participating in the design of the R and D projects.

C. The R and D institutes' internal performance and the commercialization of their outputs

27. The performance of RDIs in connection to the second phase of the innovation process -- i.e. the technical solution of R and D project ideas -- can be measured by their outputs in the form of new or improved products or processes. This phase is an important precondition for technological innovation. However, it is not sufficient to look at the RDI's internal performance. Equally important is the commercialization phase of the innovation process, which shows to what extent research output has found application in the corresponding industries. This last phase of the innovation process is of crucial importance as it determines whether successful technological developments have an impact on the economy.

28. Although it is not possible to arrive at comparable measures of the quality of the generated outputs it was found that most of the surveyed institutes had developed sufficient technological capabilities. Moreover, the internal efficiency, estimated by the number of improved products or processes appeared, to be high in almost all surveyed RDIs. In contrast to this impressive invention activity only a few research results found commercial application.

1. Indonesian RDIs

29. The surveyed RDIs in Indonesia have shown a high rate of output generation. However, their commercial application has varied considerably among the RDIs. It is of interest that industry-demanded development work as opposed to self-initiated work has shown a higher rate of industrial application. Furthermore, the highly specialized RDIs appear to have achieved a higher rate of commercialization of their outputs than the others. The institutes' generally strong liaison with public enterprises contrasts with their limited impact on the private industries.

30. The MIDC has generated about eleven major product or process inventions between 1982 and 1986. However, with a few exceptions, it has encountered difficulties in applying its research results industrially (e.g. prototype of palm oil equipment or frame and head for lathes). The ITB LAPI completed over 50 projects per year during the same period. To the extent that these projects were industry-demanded they turned out to be valuable contributions, mainly for trouble-shooting in public enterprises. In contrast to the industry-demanded projects, the majority of self-initiated R and D outputs found little commercial application.

31. The LEN and LKIM showed some successful development works, which were applied by industries. The LEN contributed in co-operation with multinational companies such as Bell telephone laboratory of Belgium, NEC of Japan and Siemens Phillips of the Federal Republic of Germany and the Netherlands, to the successful commercialization of satellite earth stations, telephone exchange systems and telefax systems. The LKIM has well-established links with enterprises to assist in the adaptation of imported technology. Moreover, some valuable contributions were made in high technology areas (e.g. telemetric control). Regarding the LKIM's self-initiated development work it has designed and produced over sixty products and processes between 1981 and 1986; out of these, 23 were utilized by government enterprises, 19 by the defense department and about 20 by private firms. The successful developments include electric meters, microscopes, glass-blowing equipment and electricity-wiring.

2. *Sri Lankan RDIs*

32. All surveyed institutes in Sri Lanka appeared to be very active in initiating and producing product and process improvements. This impressive internal performance contrasted with the low commercialization rates, whereby the industrial RDIs and the agricultural R and D institutes showed marked differences.

33. The two surveyed multi-purpose institutes which service the industrial sector have undertaken numerous R and D projects. However, only a small portion of their outputs could be commercialized. In table 6, the R and D activities between 1982 and 1986 of the CISIR and NERD are shown as regards their progress towards commercialization. Accordingly, only about 10 per cent of the initiated projects were used by the industry.

34. The situation was different for the single-purpose institutes, which service the agricultural sector. Here, the institutes claim a high success rate for both development and application. For example, the TRI has developed about 30 processes and products which have found application. Furthermore, the institute has obtained two patents (both local and foreign) on instant tea and a number of processes have been worked out in the laboratory which are awaiting scaling up. Similarily, the RPRDC claims a high success rate in the development and application of new products and processes (see table 7), mainly in the area of harvesting, storage, parboiling and milling. For both institutes, a well-functioning extension service is maintaining close contacts between the institutes and the clients, which are mainly farmers, public agencies involved in the storage and processing, and manufacturers.

3. *Senegalese RDIs*

35. Of the two institutes surveyed it is the ITA which is involved in product and process research and development. As presented in table 8, the ITA developed numerous products. However, only a small number have found commercial application. Successful product developments were in the grain and meat products, where a close liaison was maintained with enterprises throughout the development work. In addition, prior to the research activities, a market analysis had been carried out. Also a number of new processes were developed by the ITA, although their commercial application is very low.

D. Insufficient application of R and D outputs

36. The pilot studies showed that the surveyed RDIs have established technological capabilities which represent an important potential for contributing to technological innovation in the corresponding industries. However, most of the technically successful R and D developments were not used by the industries and, therefore, remained without economic impact. Although the degree of utilization of R and D outputs varied considerably among the surveyed RDIs, the overall low industrial application of R and D results was a major problem of all surveyed institutes.

37. In order to identify factors that hinder the application and diffusion of R and D outputs, questionnaires, supported by interviews, were sent to enterprises. The objective had been to identify the nature of the links between the firms and the RDIs and to compare the firms' requirements with the RDIs' outputs.

1. *Interviewed firms and their technological needs*

38. The technological requirements or the demand for technological innovation varied considerably in the countries and industries surveyed, depending on the area of specialization, the degree of export orientation and foreign co-operation and the complexity of the applied techniques. Thus, the 12 interviewed Senegalese food industries emphasized the need for locally manufactured spare

Table 6

Projects undertaken for product/process development by NERD and CISIR during 1982 - 1986

(Numbers)

R and D Institute	Projects undertaken	Products/ processes commercialized	Projects completed but not yet commercialized	Projects at development stage
CISIR	19	2	5	12
NERD	36	3	16	17

Source: Based on information provided by CISIR and NERD.

parts, adjustments of process techniques to variable outputs, improved techniques for packaging and quality improvements of products through standardization and quality control. Among the 25 most important Sri Lanka enterprises, 20 replied to questionnaires and 14 were interviewed. The technological needs of most of the firms were the adaptation of imported technology, upgrading of process technologies, improved raw material utilization and trouble-shooting in the production process. The technological requirements of the seven interviewed Indonesian firms differed markedly owing to their different degrees of specialization (aircraft, armaments, telecommunication, general engineering, machine tools).

2. *Factors underlying the insufficient application of R and D outputs*

39. The insufficient application and diffusion of R and D outputs was mainly due to the manner in which projects were originally designed and the extent to which potential users were included during the various phases of the output generation. Since, with the exception of the Indonesian institutes LKIM and ITB LAPI and the Sri Lankan agricultural institutes, user-demanded projects were of minor importance, the question was why RDIs and potential users were not co-operating more closely. As a result of the empirical investigations, three separate causes could be identified, namely a general lack of communication, the incompatibility of R and D outputs with the technological requirements of potential users and inadequate arrangements for the implementation of research outputs.

40. The reasons for insufficient links are exemplified by the replies given by the Sri Lankan enterprises which responded to a questionnaire (table 9). Regarding the usefulness of in-house designed R and D projects, the majority of the enterprises considered R and D outputs as having not a great relevance to their technological needs (table 10).

Table 7

R and D projects undertaken by the Rice Processing R and D Centre (RPRDC), 1982 - 1986

	Harvesting and threshing			Cleaning and drying					Storage					Parboiling and milling					Product development and quality improvement				
	84	85	86	82	83	84	85	86	82	83	84	85	86	82	83	84	85	86	82	83	84	85	86
1. Number of projects which led to application	1			2	2	1	2	-	1	-	2	-	1	4	1	1	3	2	2	1		2	2
2. Number of projects which are at development stage		5						1	1	1	1		1	1		2	1	1			1	1	1
3. Number of projects which did not go beyond prototype						1					1												

Source: Based on information provided by RPRDC.

Table 8

Development of new products by the Institut de Technologie Alimentaire

Raw materials	Products which were successful from the technological standpoint	Products which have reached the application stage
Grains	Millet flours for breadmaking and couscous, millet bread, millet-based cakes, millet croissants, milk loaves, broken millet, millet semolina (sankhal), instant couscous, weaning foods, millet-based beverages (M'Bou millet), millet biscuits, millet flour for pastry and pancakes	Millet semolina (sankhal), broken millet, couscous, pamiblé
Fruits and vegetables	Preserves of: papaya, mango, watermelon, bissap, melon, nadio; Jams of: mango, guava, ditakh, papaya, sweet potato, watermelon, nadio, jujube, melon, sweet potato and monkey bread, papaya and monkey bread, mango and monkey bread, mango and jujube, papaya and jujube; Syrups of: bissap, tamarind, lemon, orange, ginger; Nectars of: mango, papaya, watermelon, made; Beverages made of the following fruits: bissap, tamarind, guava, lemon, grapefruit, orange, ginger; Fruit compotes of: mango, papaya, watermelon, melon, cajou apple; Preserves of: green beans, "sower", gumbo, double tomato concentrate, pimento.	Nil
Meat	Dry beef sausages, liver pâté, bovine meat, ham, cooked beef salami, salt beef, pickles, smoked and dried beef tongues, beef merguez, pressed beef, minced beef, chopped beef, beef luncheon meat, beef brain pâté, Dakar sausages, Dakar cocktail sausages, beef liver sausages, brain sausages, seasoned beef, beef in its juice, meatballs in tomato sauce, beef tripe, garnished sauerkraut, luncheon beef fish, poultry pâté, tongue pâté	Dakar beef sausages, beef, ham, beef merguez
Fish	Thiof meetballs, pike meatballs, shrimp-dressed meatballs, white pâté of sardinelles, sardinelles and tomato pâté	Sardinelle pâté

Source: Based on information provided by the Institut de Technologie Alimentaire (Senegal).

Table 9

Reasons given by respondents for apparent lack of effective links between R and D institutes and industry in Sri Lanka

Reason given	Total (out of 20 industrial firms studied	Sector		
		Chemical industry	Agro-food industry	Metal-working and machine-building industry
Institutes lack of knowledge of industrial problems	4	1	2	1
Absence of a strong industrial liaison and technical extension activity	7	4	2	1
Lack of a market which understands or needs research services	3	-	2	1
Lack of information on R and D institutes activities output	4	2	1	1
Other	2	1	1	-

Source: Information based on firms' replies to questionnaires.

(a) Lack of communication between the R and D institutes and potential users

41. It was generally felt that insufficient communication was a major reason for the low co-operation. The communication gap was felt on both sides. Enterprises were not, or not fully, aware of the RDIs' activities. This was particularly felt by small-scale enterprises in Senegal and Sri Lanka. In Senegal, only four out of the 12 enterprises interviewed had attempted to make use of the institutes' services. These firms were also less capable of articulating and specifying their technological requirements. Regarding the RDIs, the absence of industrial liaison and extension activities was a major barrier to establishing links with clients.

(b) Incompatibility of research outputs and technological needs

42. In all three countries, potential users considered in-house initiated R and D outputs as having little relevance to their actual requirements. The firms interviewed often found the R and D outputs were too academically oriented. An interesting exception was the Sri Lankan single-purpose institutes where more than half of the firms considered the outputs to be of relevance. A strong liaison service ensured that the technological requirements of the clients were taken into account.

Table 10

Ranking by respondents of the relevance of Sri Lankan R and D institutes' output to their firm's technological needs

	Sector			
Ranking of relevancy of R and D institutes' output to technological needs of firms	**Chemical industry**	**Agro-food industry**	**Metal-working and machine-building industry**	**Total (out of 20 respondents)**
Number of firms which consider R and D output of no relevance	2	1	3	6
Number of firms which consider R and D output of little relevance	3	2	1	6
Number of firms which consider R and D output of some relevance	1	2	-	3
Number of firms which consider R and D output of great relevance	2	3	-	5

Source: Information based on firms' replies to questionnaires.

(c) *Inadequate arrangements for the implementation of research outputs*

43. A number of other factors causing insufficient application of R and D outputs and a lack of links between the institutes and the firms were related to the organizational and managerial characteristics of the RDIs. A lack of marketing by the institutes, which manifested itself in insufficient provisions for dissemination of results or inadequate facilities for demonstrating the technological viability of process and product developments (e.g. through laboratory or pilot demonstration), was regarded as a major factor which hindered industrial application. Moreover, most R and D activities were not based on economic feasibility studies that took into account the actual market situation and production cost aspects. Such studies were regarded as important for demonstrating the economic viability of inventions. Furthermore, the reluctance of firms to take over the financial risks when investing in new products or processes appeared to hinder the application of R and D outputs. This risk aversion was, in a few cases, aggravated by the inability of RDIs to grant exclusive rights for the utilization of their inventions.

E. The role of technical services and training

44. The provision of services and training formed an important activity of the surveyed R and D activities, accounting on average for about 50 per cent of total resources. The building up of service capabilities and the provision of specialized training does not fall within the different phases of R and D process (project selection, technical solution and commercialization). Service capabilities, once they are established, may be utilized as long as there is a demand.

45. The type of technical services offered by the surveyed RDIs were mostly in response to actual bottlenecks in the various industries. In many instances, these services were not available elsewhere and the RDIs' activities filled these gaps. Accordingly, the technical services were generally found to be in line with the actual requirements.

46. The spectrum of technical services and training programmes provided by the surveyed RDIs varied according to the area of specialization of the institute. The most important services were physical testing and chemical-material analysis, quality improvement of products including standardization, technical assistance and consultancy services, repair and maintenance of equipment and machinery and training of industrial personnel.

47. In general, these services addressed technologically less complex activities, aimed at improving process efficiency and product quality. It was found that all RDIs have succeeded in building up the necessary capabilities to provide these services. Regarding the utilization of the RDIs' service capabilities it was found that these services had an immediate positive impact on the industry performance. However, it was felt that this potential was not fully utilized.

48. In the case of Indonesian institutes, the training of skilled manpower and the provision of testing and advisory services were in high demand, particularly in firms which applied less complex techniques. However, supply-side bottlenecks, in particular insufficient dissemination of the institutes' capabilities, limited the contribution to firms which were within immediate proximity of the RDIs.

49. In Senegal quality control and training of technicians was of particular importance for small-scale enterprises. Major barriers to an increased utilization of services were the shortage of skilled personnel, particularly within the ITA, insufficient efforts to market the services and the dominant role of foreign technology suppliers. Neither of the two surveyed institutes had developed sufficient expertise to provide services to adapt and improve on imported technology.

50. In Sri Lanka, technical services and provision of training were an important activity of all surveyed institutes. For the industry-oriented institutes, physical testing and chemical analysis were the most important service activities. The RDIs in the agricultural sector provided technical services including field trials and monitoring. In particular, the advisory and extension services were widely utilized and contributed to building up a closer relationship between the institutes and the clients. In general, it was found that technical services were of considerable importance to the industrial and the agricultural sectors. Despite considerable efforts, further improvements appeared to be hindered by the lack of a strong industrial liaison.

Chapter III

CONCLUSIONS AND RECOMMENDATIONS

A. General findings and conclusions

51. The empirical evidence from the pilot studies showed that the contribution of the surveyed RDIs to technological innovation varies considerably among countries and institutes. Although the RDIs operate under different economic environments and their technological capabilities encompass different degrees of specialization and technological complexities, it emerges clearly from the empirical evidence that the majority of them have not provided the hoped for spur to technological innovation.

52. The relative failure of the RDIs surveyed needs to be viewed in the wider historical context of the institution-building concepts of the 1960s and 1970s. Obviously, over-optimistic policy-formulations and their institutionalization could not act as a catalyst for industrial and technological development. Given the huge investments which have been devoted to the establishment of RDIs and the scarcity of resources, there is an urgent need to re-assess the role of RDIs.

53. Although generalizations need to be treated with caution since the RDIs surveyed function in different economic environments, the findings of the pilot studies do allow for some general observations. From the assessment of the different functional activities of RDIs in line with phases of innovation and actual demand requirements, four central issues emerge:

(i) The relatively greater importance of technical services in line with technological needs and levels of development of the corresponding industries as compared to pure R and D activities;

(ii) The role of RDIs in the accumulation of specific technological capabilities, regardless of their immediate industrial utilization;

(iii) The importance of demand orientation of R and D activities;

(iv) Institutional aspects which hinder or stimulate the RDIs' performance.

1. Industrial services versus pure R and D activities

54. Regarding the relative importance of industrial services, the pilot studies showed that, on average, about 50 per cent of the total R and D activities were related to industrial services and training. It was generally recognized that these services had an immediate positive impact and that the RDIs' service capabilities and training facilities were in line with the industries' requirements. Generally, these services addressed technologically relatively less complex activities, aiming at improving process efficiency and product quality.

55. The need for industrial services was particularly pronounced in technologically less developed industries, where basic problems of production -- such as maintenance, standardization, testing, quality control and trouble shooting -- form major barriers for improving performance. The relevance of technical services in line with the technological development level of the industries contrasts with the relatively small importance of pure R and D activities. Thus, in Senegal, R and D outputs had hardly been commercially applied, while there was a huge demand for technical services. In Sri Lanka, the single-purpose RDIs serving the relatively specialized and highly developed agricultural sector played an important role in generating and commercializing improved or new products and processes. In contrast, the contribution of the multi-purpose RDIs to the technologically less specialized and less advanced industry sector regarding technological inno-

vation was modest. However, the RDIs' service capabilities were in high demand and were generally viewed as having a positive impact on the industry's performance.

56. In Indonesia, the situation is less clear. There have been several cases where pure R and D activities have made an important impact on the industries. These contributions have often been in high-technology areas where there is long-term government involvement and in co-operation with multinational companies. Regarding research activities which target less developed industries, the situation appears to be similar to Sri Lanka: technical services are in high demand and the contribution of pure R and D activities is limited, particularly in cases where projects are conceived in-house.

57. Overall, it appears that immediate benefits of the RDIs' functional activities in terms of pure R and D activities and technical services is largely determined by the level of technological development of the corresponding industry.

2. Technological capabilities of the surveyed R and D institutes

58. Despite the generally low contribution of the surveyed institutes to industrial innovation, they have accumulated sufficient expertise and technological know-how to offer industrial services or to generate improved products or processes. The latter was confirmed by numerous technologically successful development works and a generally high inventive activity. The fact that a large share of this product and process development work remained uncompleted or on the shelf does not invalidate their technological novelty and potential commercial usefulness. Particularly when considering the technology content of the produced R and D outputs, one would conclude that the institutes have made a significant contribution to the formation of skills and the accumulation of specific knowledge. Such embodied knowledge might be beneficial to firms and industries through movements of skilled personnel. However, it is not possible to arrive at an overall assessment of the RDIs' contribution to the formation of human capital since cost/benefit comparisons for alternative skill formation schemes are not available and because it is not clear to what extent the acquired skills will be actually utilized.

59. Regarding the type and level of acquired technological capabilities and corresponding skills, they depend notably on the overall structure of the RDIs and on the technological development level of the industries. Thus, the single-purpose institutes in Sri Lanka and Indonesia have specialized capabilities which mirror the corresponding industries' *status quo*. In Senegal, basic bottlenecks of materials supply and handling, production techniques and organizational aspects of the industry conform with a more diversified but less specialized skill-profile of the RDIs. In Sri Lanka, the single-purpose institutes in the agricultural sector have accumulated highly specialized skills -- for example in tea processing -- whereas in the industrial sector, the skill profiles of the RDIs are rather diversified and less specialized.

3. Demand orientation of R and D activities

60. A major observation of all three country studies is the generally weak link between the RDIs and the corresponding industries. Regarding the functional activities of the RDIs, this weakness was less pronounced for technical services, although an even closer interaction in that area was regarded as desirable. The weak link was apparent in a general lack of communication, insufficient liaison and extension services.

61. A major underlying cause of the weak links was the insufficient demand orientation of the RDIs, which was evident in all phases of the innovation process. Generally, R and D projects were in-house conceived and potential users had little impact on the design. The financial viability was not adequately examined and during the phase of output generation there was little interaction with potential clients. Consequently, R and D outputs were often viewed by the industries as not being relevant -- a fact which, reinforced by the RDIs' weak marketing capabilities, led to the non-utilization of R and D outputs.

62. The positive experiences of some Indonesian and Sri Lankan institutes as regards industry-demanded or contractual research show that an early participation of potential users is a promising approach for ensuring a successful application. Quite obviously, the participation of potential users during the design phase as well as a continous exchange of experiences and views during the phase of output generation ensures that important market aspects and production characteristics are taken into account. This approach has a two-fold advantage over in-house initiated outputs. First, the commercial viability, which is crucial for a successful application, is recognized at an early stage and unviable projects have less chance of being carried out; and secondly, the inclusion of users faciliates the later application of results since the user is already acquainted with the technical characteristics of the output and the RDIs may incorporate in their research important aspects from the user's point of view.

63. An interesting observation of the pilot studies is the different degrees of demand orientation in correspondence with the degree of specialization of the RDIs. It appears, that RDIs which are more specialized achieve a higher degree of demand orientation as regards their R and D outputs. This was the case in the single-purpose Sri Lankan institutes in the agricultural sector, in particular the Tea Research Institute and the Indonesian LKIM and the LEN, which focused on specific technologies. Usually, these institutes remain in close contact with the industries by monitoring their requirements and by maintaining close liaisons.

64. Finally, it is of interest to look at the ownership structure of industries which make use of the RDIs' services. In general, foreign-owned enterprises or local enterprises associated with foreign technology suppliers were the ones that appear to make the least use of the RDIs' activities in Senegal and Sri Lanka. The reasons for this were the relatively easy access to the technological services of external technology suppliers and the lack of confidence in the RDIs' capabilities. Regarding public and private enterprises in all three countries, the former are the ones that make most use of R and D services.

4. Institutional aspects

65. Another set of observations relates to organizational and supply-side factors. Although these aspects are of importance for making possible an effective functioning of the institutes, they have not been a major interest in the pilot studies.[8] In general, the pilot studies confirmed that the introduction of more efficient management structures, including the breakdown of objectives into measurable goals suitable for promoting and assessing performance, the introduction of commercial cost/benefit concepts and financial incentives, more emphasis on industrial experiences, the removal of bureaucratic obstacles by increasing the institutes' autonomy and the provision of means to overcome supply-side bottlenecks (e.g. prototype development) could have positive effects on the institutes' performance.

66. Among these measures, a change in the mode of financing RDIs' budgets is particularly promising for technical services since their cost-benefit profile is directly related to the volume and quality of industry-relevant activities. Coupled with the introduction of financial incentive schemes, revenues from clients' fees would stimulate the internal efficiency and improve the demand orientation. Thus, a wider range of clients would benefit and particular efforts to sell services to private enterprises could have positive feedbacks on the quality of the services. At the same time, it could help to overcome a major supply bottleneck, namely the inability of the RDIs to retain qualified personnel.

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[8] For a review of institutional building concepts and problems see UNIDO, *Joint UNDP/UNIDO evaluation of IRSI's*, Vienna, 1980.

B. Recommendations

67. Although the pilot studies allow only very limited general conclusions, to be drawn, their findings may offer useful points of departure for improving the contribution of RDIs. In general, it appears that the role of RDIs needs to be viewed in the context of the corresponding industries' requirements, which in turn is a function of relative levels of technological development and specialization. Based on this understanding it is possible to derive three general recommendations.

68. First, there is a need to switch the emphasis from supply-side aspects to the demand side in order to bridge the gap between the RDIs' activities and the actual requirements of the potential clients. General measures such as establishing capabilities to monitor and evaluate market requirements by, for example, strengthened liaison functions, increasing marketing efforts particularly regarding technical services, and institutional measures, such as fees-based financial incentive schemes, might be helpful in this direction. Moreover, attempts need to be made to increase the participation of potential clients during all phases of product or process development. The stimulation of contractual research and the introduction of financial risk-sharing schemes could be supportive in this respect.

69. Secondly, it appears that single-purpose and specialized RDIs perform relatively better because they have a higher degree of technical competence and market knowledge. This argues in favour of developing specialization in priority areas of technical requirements, rather than spreading the limited resources too thin.

70. Thirdly, it is necessary to distinguish clearly between basic R and D activities and technical services, and eventually to reallocate resources in favour of the latter, depending on the industries' requirements and the availability of resources.

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Transfer and development of technology in the least developed countries: an assessment of major policy issues

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Carleton University, Ottawa, and
LAREA/CEREM, Université de Paris-X

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INTRODUCTION

1. Developing countries are increasingly concerned with matters related to technology, concerning both its acquisition from abroad and its domestic adaptation, generation, and diffusion. Their efforts seem to converge towards adapting and strengthening their technology policies and institutional arrangements so as to make them more responsive to the new challenges to trade and development in the present international economic environment, characterized by rapid technological change. The least developed among these countries appear, however, to be particularly affected by constraints in attempting to bring about the technological and structural changes required for their development in a changing economic environment.

2. It is in this context that the Committee on Transfer of Technology, at its seventh session, in January 1989, requested the Secretary-General of UNCTAD to make an in-depth assessment, as part of the preparations for the Second United Nations Conference on the Least Developed Countries for the global review and appraisal of the Substantial New Programme of Action, of the special technology problems faced by the least developed countries in the development and strengthening of their technological capability.[1] In conformity with the above request by the Committee on Transfer of Technology, the UNCTAD secretariat has prepared the present report.

3. With the decline in productivity growth and the rise in inflation and unemployment that characterized many advanced industrial countries in the 1970s, the world economy entered a period of turbulence and change, giving impetus to a process of adjustment. Several important changes in the world economy and in the structure of production took place during the 1970s and 1980s. The most salient of these, for the immediate purposes of this report, were the heightened pace of global competition and the accelerated rate of technological innovation and diffusion. Even in traditional industries, of which textiles and clothing are prime examples,[2] the need to improve the competitivenes of domestic productive capacity led to the internationalization of production and to a rapid increase in the knowledge-intensity of production, where knowledge is understood to include research and development, design, process engineering, production engineering, maintenance, management and marketing. To capture the changing nature of production and the strategies required to deal with it, the concepts of technology and technological change encompass these knowledge capabilities and the machinery, tools and equipment through which production understood as the process from conceptualization to the market is carried out.

4. As the knowledge-intensity of production increases, technology in this broad sense can no longer be regarded as a "cost" of modernization but needs to be seen as an investment in competitiveness. It thus becomes a vital link in the relationship of trade to development, where the latter is conceived not as a finite end but as a continous process of transformation, adaptation and adjustment in advanced industrial and developing countries alike. The growing uncertainty that results from the rapid pace of technological change and the extensive internationalization of capital and production, moreover, has placed a premium on flexibility and innovativeness in the adjustment process. At no time, therefore, has the building of indigenous technological capabilities in developing countries assumed as much urgency as it has today.

5. An assessment of the current situation in the least developing countries, however, reveals the extent to which they are ill-equiped to deal with the challenge to development posed by accelerated technological change. Chapter I of the present report examines, *inter alia*, the structural weaknesses of the LDCs, which are obstructing technological change, i.e. their extremely limited capacity to import technology, particularly because of their weak foreign exchange earning capability, and their inadequate inducement mechanism on the demand side for technological change. This is explained, among other things, by an import-intensive model of industrialization relying heavily on foreign investment, or on external loans for capital, on expatriate management for know-how and on imports of machinery, equipment and intermediate goods. In other words, a model that is characterized by an "assembly orientation", heavily dependent on imported inputs

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[1] See Resolution 32 (VII) para. 10. Elements of the report prepared have also been integrated into UNCTAD, The Least Developed Countries 1989 Report, (TD/B/1248), as Section D, "Policies Issues in the Transfer and Development of Technology", Chapter II "The Productive Base: Policies Towards Modernization".

[2] UNCTAD, Trade and Development Report, 1987, pp. 155-160.

and almost void of demand for technological change and innovation, thus lacking the stimulus that industry could provide for the development of local engineering capabilities. The report also examines the limited technology supply capabilities of the LDCs and the impact of traditional structural adjustment programmes. It further considers technology flows to the least developed countries through the three major channels of technology transfer - capital goods imports, foreign direct investment and foreign aid. Of the three, only the latter has been important for most of the LDCs. During the 1980s, many of these countries liberalized their foreign investment policies, streamlined and rendered more transparent their foreign investment procedures and signed bilateral agreements for investment promotion and protection. Despite such policy changes which, under earlier conditions, might have made the LDCs more attractive to foreign investors, actual recorded flows have been small, diminishing both absolutely and relative to similar flows to other more developed developing countries, which also point to stagnation.[3]

6. Chapter II of the report includes an examination of 13 case studies based on material from a representative grouping of eight least developed countries - Bangladesh, Nepal and Tuvalu in Asia; the United Republic of Tanzania, Rwanda, Togo, Benin and Sierra Leone in Africa - and covering issues related to technology acquisition, utilization, absorption and innovation in raw material and food processing, several of the basic industries in the LDCs and a number of agricultural sectors, and service and training activities. The case studies touch upon some of the fundamental problems and dilemmas faced by donors, host Governments and a variety of economic and social actors with respect to the relationship of technology to development. The broadest of these problems concerns the design of the development policies and aid programmes themselves. Considerably more emphasis has traditionally been placed by policy-makers in donor and least developed countries on the transfer of technology than on its domestic development, and within this framework on the transfer of machinery and equipment rather than know-how. More often than not, the lack of participation by users in the process of choice and inattention to the process of technological mastery have led to problems in production and difficulties for sustainability. However, successful cases of technological innovation have illustrated that advances in productivity and major gains in income can be obtained through changes in organizational technology, greater participation by technology users in the process of technology choice, efforts to improve indigenous techniques and to innovate on the basis of imported technology and programmes that combine the provision of production skills and of credits. A number of policy findings and recommendations flow from the analysis of the above elements, which are organized in chapter III around three principal themes: rethinking the resource question; building a commitment to technological change; and shaping the domestic environment for technology absorption and innovation: the role of policies and the strengthening of the human resource base.

7. Extensive use was made in the preparation of the report of a background paper prepared at the request of the secretariat by Lynn Krieger Mytelka, Carleton University, Ottawa and LAREA CEREM, Université de Paris-X, and of written comments by the following persons: Mr Iftikhar Ahmed, Technology and Employment Branch, Employment and Development Department, International Labour Office (ILO), Geneva; Mr M.N.B. Ayiku, Project Co-ordinator, Technology Transfer Centre, Accra; Mr Claes Brundenius, Deputy Director, Research Policy Institute University of Lund, Lund; Mr Arthur Camara Cardozo, Asesor para Asuntos Internacionales, Instituto Nacional da Propriedade Industrial (INPI), Rio de Janeiro; Mr F. Eliott, Chief, Technology Section, Division of Industry, Human Settlement and Environment ESCAP, Bangkok; Mr Calestous Juma, Executive Director, African Centre for Technology Studies, Nairobi; Mr Sam Lanfranco, Economics Department, Atkinson College, York University, Ontario; Mr Rasto Macus, Senior Adviser, International Centre for Public Enterprises in Developing Countries, Ljubljana; Mr M cDonald Mwinjilo, Bunda College of Agriculture, University of Malawi, Lilongwe; Mr Masafumi Nagao, Sasakawa Peace Foundation, Tokyo; Mr K.D. Sikka, consultant, New Delhi; Mr Jaime Alvarez Soberanis, Dirección Ejecutiva de Consultoria Jurídica de la Comisión Nacional de Valores, Mexico; Mr Samuel M. Wangwe, Senior Research Fellow, Centre for Development Studies, Bergen; and University of Dar-es-Salaam, Faculty of Arts and Social Science, Dar-es-Salaam. The UNCTAD secretariat, and in particular, the Advisory Service on Transfer of Technology, Technology Programme, expresses its appreciation for their assistance.

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[3] See also UNCTAD, "Recent trends in international technology flows and their implications for development" (TD B C.6 145).

Chapter I

TECHNOLOGICAL CHANGE AND THE STRUCTURAL WEAKNESSES OF THE LEAST DEVELOPED COUNTRIES IN A CHANGING ECONOMIC ENVIRONMENT

A. Technological change and the structural weaknesses of the least developed countries

8. More than most developing countries, the least developed countries (LDCs) are singularly unprepared to meet the challenges of a changing technological and competitive environment, while continuing to face most critical national development needs. As this and successive chapters will show, they lack the strong knowledge base, integrated physical infrastructure and diversified economy required to weather shocks and recombine existing resources in new ways to adjust to what has become a continuous process of change. They also lack the institutional mechanisms and capabilities to perceive opportunities and constraints and to translate these into effective policies for change. The financing and skills needed to innovate, to adapt and to diversify are also exceedingly rare in these countries.

1. Technology and the SNPA

9. As early as 1964 attention focused on the least developed countries and a first United Nations resolution on the subject was adopted at UNCTAD II in 1968.[4] Not until 1971, however, were the three principal criteria used to identify least developed countries approved and a list of 24 countries meeting these criteria drawn up (see table 1).

10. These criteria, per capita GDP of $US 100 or less, a share of manufacturing in total GDP of 10 per cent or less and adult literacy of 20 per cent or less, continue to define a category of countries whose membership has expanded over the last quarter of a century to 42. More disappointing still is the fact that no single country from among the original 24 has left the "least developed" category and there are many signs that the gap between the least developed and other developing countries is widening.[5]

11. By 1981, therefore, a Substantial New Programme of Action (SNPA) was enacted to promote "the structural changes necessary to overcome the extreme economic difficulties" of the LDCs; provide "fully adequate and internationally accepted minimum standards for the poor", identify and support investment opportunities as these countries defined them and mitigate "as far

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[4] "Special measures to be taken in favour of the least developed among developing countries aimed at expanding their trade and improving their economic and social development" Resolution 24 (II).

[5] World Bank figures show, for example, that GDP in billions of US dollar in the low-income economies fell from 77.9 per cent of the GDP in middle-income economies in 1965 to 57.1 per cent in 1973, 47.7 per cent in 1980 and was estimated to be only 41.1 per cent in 1988. Calculated on the basis of figures from IBRD, World Development Report 1989, Table A.3. Growth rates of real GDP also show that between 1970-1980 the least developed countries averaged 3.6 per cent year whereas GDP in all developing countries grew at an average rate of 5.5 per cent. Although average growth rates of real GDP in the LDCs fell to 2.8 per cent in the period 1980-1983, they were higher than the 1.6 per cent per year registered by all developing countries. In the period 1983-1986, however, average growth rates of real GDP in the LDCs fell again to 1.5 per cent per year whereas those in all developing countries rose to 2.7 per cent. Calculated from UNCTAD, **The Least Developed Countries 1988 Report** (New York, 1989) Table A.4.

Table 1

The least developed countries: [a] population and per capita GDP

Per Capita GDP [b]	< 5 million population	5-25 million population	> 25 million population
< $200	*Bhutan Guinea Bissau *Lao P.D.R. *Lesotho	*Burkina Faso *Chad *Malawi *Mali Mozambique *Nepal Tanzania	Bangladesh *Ethiopia
$200-39	*Benin *Burundi Cape Verde Central Af.Rep. Comoros Equat.Guinea Gambia Kiribati Sao Tome & Prin. Sierra Leone Togo Tuvalu	*Afghanistan *Guinea Niger *Rwanda *Sudan *Uganda	Myanmar
$400-599	*Botswana [c] Democratic Yemen Djibouti *Maldives Mauritania *Samoa	*Haiti *Somalia *Yemen	

AVERAGE PER CAPITA GDP

All Least Developed Countries	$ 219
All Developing Countries	884
Developed Market-Economy Countries	11080

Source: **UNCTAD, The Least Developed Countries 1988 Report, table A-3; IBRD, World Development Report 1989, table 1 for Mozambique.**

Note: *** Original group of 24 least developed countries.**

[a] Based on 1986 data.

[b] Per capita GDP in 1986 dollars.

[c] Bostwana's per capita GDP is $997.

as possible the adverse effects of disasters". With regard to technological development and change, the programme stressed the need:

(1) To develop adequate planning and managerial capabilities for the identification and preparation of investment projects and the evaluation, negociation and registration of technology transfer operations.

(2) To increase output and improve productivity in both agriculture and manufacturing industry through the application of scientific research, engineering skills, and organizational changes;

(3) To develop the research and development capabilities required in the search for appropriate solutions to existing structural, organizational and technical problems including those relating to the provision of credit and of land, agricultural techniques, soil conservation, irrigation, small-scale and artisanal manufacturing techniques, institution-building, health and nutrition;

(4) To train the requisite personnel at all levels bringing women more actively into the development process; and,

(5) To build the infrastructural base and policy environment needed to induce technological change and development in the desired direction.[6]

12. A major role was envisaged for the international community in assisting the least developed countries to develop the technological capabilities identified in the SNPA. Progress towards meeting these objectives, however, has been slow as data on the flow of technology resources to the LDCs presented in this chapter's next section and case studies on the acquisition, utilisation, absorption and generation of technology by the least developed countries analyzed in chapter II illustrate. At the macro-level the difficulties encountered were also translated into disappointing results.[7] Over the 1980s, for example, Gross Domestic Product (GDP) in the LDCs fell as did their share in world trade. Life expectancy at birth remained at the low figure of an average of 46 years. The problem of debt servicing, moreover, became so acute for the developing countries as a whole and for a number of least developed countries in particular that priority attention has been diverted away from the building of technological capabilities needed for their longer term development goals and towards the short term policies needed to meet their financial obligations (table 2). As a group of eminent persons on the least developed countries concluded, such policies in the context of the "technological change and structural transformation at the international level, that is... making fast headway in quickly reshaping the world economy, create a risk of the irreversible marginalization of the LDCs".[8]

13. Debt relief is an obvious first step in overcoming the financial constraints that currently distort both policy and practice in the least developed countries. But understanding the sources of other domestic and international constraints on the acquisition, utilization, absorption and generation of technology is clearly a prerequisite to effective policy formation and implementation in these countries.

14. With regard to the problem of technological development and change, there is no single indicator nor set of indicators that serves in every instance to differentiate the least developed countries from those that compose the broader category of developing countries. Many of the LDCs" problems, in fact, are common to all developing countries. Nonetheless there are qualitative differences that derive from the specific ways in which a variety of quantiative indicators

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[6] UNCTAD, **Les pays les moins avancés et l'action de la Communauté internationale en leur faveur,** Choix de documents de la Conférence des Nations Unies sur les pays les moins avancés, (New York, 1983), p. 3-13.

[7] Declaration by the Conference of Ministers of African Least Developed Countries Preparatory to the Second United Nations Conference on Policies and Measures for Accelerating the Development Process in the LDCs During the 1990s, adopted by the Conference of Ministers of African LDCs at its Ninth Meeting, Addis Ababa, 4-5 April 1989; UNCTAD, **The Least Developed Countries Report 1988;** UNCTAD, "A Review of the Manufacturing Sector in the Least Developed Countries - the Implementation of SNPA in the Eighties and Proposals for Further Action" contribution by the United Nations Industrial Development Organization to the preparatory process for the second United Nations Conference on the Least Developed Countries, Doc. No. A Conf 147 DR 3 Add.3, 10 March 1989.

[8] UNCTAD, "Report of the meeting of the eminent persons on the least developed countries" Second United Nations Conference on the Least Developed Countries, Preparatory process for the conference, UNCLDC II 1 (17 January 1989), p.2.

Table 2

Ratio of debt service to exports for the LDCs: 1982-86

	1982	1983	1984	1985	1986
Afganistan	5	5	5	7	8
Bangladesh	23	23	28	31	46
Benin	16	38	21	21	30
Bhutan	6	6	1	24	...
Botswana	10	4	6	6	5
Burkina Faso	15	15	15	19	15
Burundi	17	24	23	20	26
Cape Verde	6	10	18	14	12
Central African Rep.	6	10	25	16	17
Chad	5	2	8	13	5
Comoros	9	11	27	12	10
Democratic Yemen	20	27	62	89	102
Djibouti	2	4	11	23	40
Equatorial Guinea	41	50	42	54	41
Ethiopia	14	20	25	25	26
Gambia	22	19	13	17	33
Guinea	24	20	24	16	24
Guinea-Bissau	23	25	28	83	86
Haiti	12	12	13	15	24
Kiribati	0	...	1	3	6
Lao People's Dem.Rep.	7	11	20	43	22
Lesotho	3	3	4	7	5
Malawi	36	32	31	40	48
Maldives	3	8	31	14	19
Mali	19	10	13	27	25
Mauritania	21	18	21	27	24
Mozambique	...	...	...	...	...
Myanmar	40	53	42	55	61
Nepal	8	9	8	7	10
Niger	39	33	31	51	50
Rwanda	6	5	12	14	12
Samoa	18	14	19	26	28
Sao Tome & Principe	4	8	11	33	29
Sierra Leone	32	43	32	31	40
Somalia	13	23	58	78	113
Sudan	25	24	28	28	52
Togo	14	20	28	30	31
Tuvalu	...	...	...	...	...
Uganda	25	33	42	45	35
United Rep.of Tanzania	22	35	27	28	35
Vanuatu	4	7	19	24	83
Yemen	24	26	53	73	128
All LDCs	19	20	23	27	32

Source: **UNCTAD, Least Developed countries 1988 Report**, Annex 49C, p. A-69.

combine in this particular group of countries.[9] It is this qualitative difference that we are attempting to capture by characterizing the LDCs" situation with respect to technology in terms of the combined effects of: (i) vulnerability; (ii) weak domestic inducement mechanisms for technological change and (iii) limited endogenous technology supply capabilities.

2. Vulnerability

15. The least developed countries are highly vulnerable to changes in their external environment and this has seriously weakened their ability to acquire and to absorb technology imports. This vulnerability is in large measure a result of the overwhelmingly rural base on which economies in the least developed countries depend and the limited amount of economic diversification and high import dependence that characterize these economies. Table 3 shows slow and sometimes negative rate of growth in manufacturing value added (MVA) over the years 1975-1987 and the declining share of GDP represented by manufacturing activity for the LDCs as a whole. Table 4 provides evidence of the concentration of the labour force in agriculture and of manufacturing activity in the processing of food and agricultural commodities in those LDCs for which data were available.

16. The limited degree of diversification is also evident in the export sector where exports are concentrated in only a few primary commodities (figure 1) and sold to a relatively small number of corporate or country clients. These factors render the least developed countries highly vulnerable to global shifts in demand and to international price fluctuations. Existing schemes, moreover, do not adequately compensate the least developed countries for non-fuel commodity shortfalls. The IMF's Compensatory Financing Facility, for example, compensates the LDCs at a rate "8 percentage points lower than their share in the total shortfalls" and this was only partly made up by the European Communities" STABEX.[10]

17. Deterioration in the external economic environment in the period following adoption of the SNPA and a fall in the price of their major exports (figure 2) further weakened the LDCs' debt servicing capacities (table 3) and diminished the ability of Government and producers to save and invest.[11] This, in turn, increased the difficulties Governments faced in sustaining policy initiatives of their own and it increased their vulnerability to policy shifts in the major donor countries.

3. Weak inducement mechanism for technological change on the demand side

18. The ability to absorb imported technology and the extent to which local technologies are generated or upgraded are also affected by the size and structure of the user consumer base. As we saw in table 1, domestic markets in the least developed countries are excessively small either because of low levels of per capita income (Nepal, Ethiopia, Malawi, Tanzania), small population size (Botswana, Democratic Yemen, Mauritania, Vanuatu) or a combination of both (Bhutan, Guinea Bissau, Lao Peoples Democratic Republic, Lesotho). But the disadvantages of small size of domestic markets is exacerbated by the type of industrialization model "modern" factories producing standardized goods and enjoying economies of scale adopted in most LDCs.[12]

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[9] The approach taken in this paper stresses both supply and demand factors in the process of innovation and diffusion. The pace and direction of technological development and change are thus not autonomous of the inducements and constraints coming from the social, political and economic environment. For a longer discussion of the inducement mechanisms and focusing devices that affect technological change see Nathan Rosenberg, **Perspectives on Technology** (Cambridge: Cambridge University Press, 1976), pp. 108-125; Lynn K. Mytelka "Stimulating Effective Technology Transfer: The Case of Textiles in Africa", in N. Rosenberg and C. Frischtak (eds.) **International Technology Transfer: Concepts, Measures and Comparisons** (New York: Praeger, 1985), pp. 77-125; Richard R. Nelson and Sidney Winter "In Search of a Useful Theory of Innovation" in **Research Policy**, No. 6 (1977), pp. 36-76 and Christopher Freeman and Carlotta Perez, "Structural Crises of Adjustment, Business Cycles and Investment Behavious" in G. Dosei et al. **Technical Change and Economic Theory** (London: Pinter Publishers, 1988), pp. 38-66.

[10] UNCTAD, **Commodity export earning shortfalls, existing financial mechanisms and the effects of shortfalls on the economic development of developing countries,** TD B AC 43 5 (8 July 1987), pp. 4-5. A full list of leading exports for individual LDCs can be found in UNCTAD, **The Least Developed Countries 1988 Report,** Annex 11, pp. A-18-19. Average annual growth rates of export value and purchasing power of exports and of import value and volume are in **Ibid.** Annexes 9 and 10 pp. A-14-17.

[11] For Africa, the terms of trade index (1980 = 100) fell from 109 in 1981 to 60 in 1987 (Assaf: 1988, 3). See Table A.7 on consumption, investment and savings in IBRD, **World Development Report 1989.**

[12] This was as true of World Bank missions to many African LDCs in this period as it was of planning documents drawn

Table 3

Manufacturing value added in the LDCs: 1975-1987

Year	Manufacturing value added In millions of US dollars (1980)	Growth rate in per cent	Share of GDP in percentages
1975	6240		8.5
1976	6316	1.21	8.3
1977	6340	0.39	8.1
1978	6338	-0.05	7.8
1979	6168	-2.67	7.6
1980	6470	4.90	7.8
1981	6430	-0.62	7.6
1982	6449	0.29	7.4
1983	6816	5.68	7.6
1984	7035	3.22	7.7
1985	7248	2.98	7.7
1986	7468	3.08	7.6
1987	7748	3.75	7.6

Source: UNCTAD, "A Review of the Manufacturing Sector in the Least Developed Countries - the Implementation of SNPA in the Eighties and Proposals for Further Action" contribution by United Nations Industrial Development Organization, A/CONF/147/DR/3/Add.3 (10 March 1989), p.32.

Note: Data for 1983-1987 concerning MVA is influenced by one country (Bangladesh).-

19. Conceptualization of the industrialization process as large-scale mass production was particularly problematic since the productive population consisted overwhelmingly of peasant farmers and artisans with low purchasing power and hence limited effective demand for new or improved technologies. The dictates of the "market" for manufactured goods thus inevitably oriented production towards urban consumers whose tastes had been shaped by imports. This made adoption of an "import-reproducing" rather than an "import-substituting" industrialization strategy more likely. These terms need clarification, especially in the present conjuncture where import-reproduction by masquerading as import substitution has tended to discredit industrialization strategies based on the internal market and to limit the extent to which efforts have been made to adjust the industrialization model to conditions in the domestic market.

20. Import reproduction strategies such as those implemented in many of the LDCs at various points in time, take "product" as their point of departure, rather than "purpose". They thus ignore the extent to which products incorporate concepts of functionality, cost, quality and esthetics that correspond to the producer's principal market of sale. An import substitution strategy, reverses this process by first, identifying the purposes embodied in imported products, then determining their relevance to the local environment and lastly by designing a product that conforms most closely to domestically available inputs, material and non-material. Reverse engineering was common in an import substitution strategy and frequently led to downscaling and other modifications to the product and process that cheapened production costs and stimulated wider domestic linkages especially to the machine-building sector.

21. Within the context of an import substitution strategy there is no automatic assumption that given product categories are homogeneous either in the characteristics of the product - its quality,

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up by technical assistants, arguments advanced by development theorists and positions embraced by most leaders in the LDCs. For a more extensive treatment of this subject and the material contained in the following paragraphs see Lynn K. Mytelka "The Unfulfilled Promise of African Industrialization". Plenary address to the American African Studies Association (Chicago: 28-31 October 1988), to be published in the African Studies Review, December 1989.

Table 4

Economic diversification in selected LDCs in 1986

	Percentage of labour force in agriculture	Percentage distribution of MVA [a]		
		Food and agriculture	Textiles, clothing	Machinery, transport and equipment
Afghanistan	57	...	...	...
Bangladesh	71	26	36	6
Benin	65	58	16	0
Bhutan	91	...	...	...
Botswana	66	52	12	0
Burkina Faso	85	62	18	2
Burundi	92	...	...	...
Cape Verde	47	...	...	...
Central African Rep.	67	...	...	...
Chad	78	45	40	0
Comoros	81	...	...	...
Democratic Yemen	35	...	...	...
Equatorial Guinea	60	...	...	...
Ethiopia	77	51	23	0
Gambia	82	...	...	...
Guinea Bissau	80	...	...	...
Haiti	66	...	...	...
Lao People's Dem.	73	...	...	...
Lesotho	82	12	20	0
Malawi	79	...	...	...
Mali	83	...	...	...
Mauritania	67	...	...	...
Myanmar	49	...	...	...
Nepal	92	...	...	...
Niger	89	...	...	...
Rwanda	92	77	1	0
Sierra Leone	65	65	1	0
Somalia	72	46	21	0
Sudan	65	22	25	1
Togo	71	...	...	...
Uganda	83	...	...	...
United Rep.of Tanzania	83	28	26	8
Yemen	65	...	...	...

Source: Percentage share of labour force in agriculture figures are from UNCTAD, The Least Developed Countries 1988 Report, Table A-6. Distribution of manufacturing value added figures are from IBRD, World Development Report 1989, Table 6.

Notes: "..." not available.

[a] Manufacturing value added.

size, colour, material inputs and design or in the processes through which it is produced. The reduction of imports as a share of domestic consumption thus occurs without requiring that the locally made product be identical to the formerly imported one. The logic and economics of import reproduction strategies, on the other hand, are such that the tendency is not only to reproduce the characteristics of imported products but to do so with technology similar if not identical to that used in the original market of manufacture.

22. Not only is the practice of import substitution different from that of import reproduction but its teleology differs as well. Thus in a process of import substitution "production" is not the sole end. Rather, it becomes part of a more complex process of technological learning that encompasses product specification and design, process choice and change and the social organization of production. In this fashion technological mastery becomes part of the process of industrial deepening and the qualitative changes in the structure of production that this implies. In contrast import reproduction strategies shift our attention away from these dynamic learning effects and towards quantitative indicators of output growth. The long-term consequences of this orientation for technology acquisition, utilization, absorption and generation will be brought out in greater detail through the case studies discussed in chapter II.

23. Here, however, it is important to emphasize that the choice of an import reproduction model had an immediate impact on the industrialization process and the ability of domestic industry to absorb imported technology, utilize it efficiently and build upon it. First, its implementation required that Governments in these countries design an institutional system that would overcome the imperfect fit between the capital and technology requirements of this model and domestic factor markets. Tax, tariff, credit and income policies were thus adopted to attract investors and ensure the profitability of their investments. Ultimately this led to an industrialization process that relied heavily on foreign investment and when such investment was not forthcoming, on external loans for capital, on expatriate management for know-how and on imports for machinery, equipment and intermediate goods. An additional feature was the "assembling orientation" of the import reproduction model, with heavy reliance on imported goods, resulting on an operation almost void of demand for technological change innovation. The import intensity of production in this model increased the vulnerability of industry in those developing countries pursuing an import-reproduction strategy, to shortfalls in earnings from primary commodity exports, contributing thereby to the high levels of underutilized capacity there. From a technology perspective, reproducing imported products, moreover, made rational a strategy of sourcing technology abroad thus weakening the stimulus that industry could provide for the development of local engineering capabilities.

24. Second, there also existed a gap between the import reproduction variant of the mass production model in which existing imports by a small urbanized segment of the population guided the choice of what to produce locally and the potential size and share of the domestic market for similar, though not identical, products. An import reproduction strategy thus led to an inability and in some cases an outright refusal to consider "informal sector" activities as bona fide sources of industrial and technological capabilities. Little effort was expended in developing such activities and in many countries informal sector actors were subjected to considerable harrassment. One of the sectors most seriously affected by this attitude was agricultural machinery where as a recent UNIDO report stressed few efforts have been made to improve upon indigenous techniques of production or develop a local agricultural machinery sector. As a result, the "agricultural machinery industry today employs less than 1 per cent of the total industrial labour force. Its output...accounts for less than 10 per cent of the total market for agricultural machinery, which means near-total dependence on foreign technologies and suppliers".[13]

25. Third, in a highly protected environment with limited domestic competition, incentives to move along the learning curve and become efficient producers even within the constrained contexts of their small domestic markets were largely absent. The structure of industry and the policy environment within which it operated thus did not induce technological change either.

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[13] UNIDO, **Agricultural Machinery and Rural Equipment in Africa**, A New Approach to a Growing Crisis (Vienna: UNIDO, Doc. No. UNIDO IS.377, 25 March 1983), p. 9.

4. *Limited technology supply capabilities*

26. In addition to weak inducements for technological change coming from the demand side, a number of factors constrain the domestic supply of technology in the least developed countries. First, least developed countries are seriously deficient in skilled personnel especially at the technical and managerial levels. World Bank figures for 23 least developed countries show an average of only 12.8 per cent of the relevant age group enrolled in secondary schools and only 2.2 per cent in higher education in 1986.[14] While no separate figures for the LDCs exist, using African data as a rough proxy shows that research and engineering capabilities are also excessively scarce. Whereas the estimated number of scientists and engineers engaged in R and D per million population for 1980 in the developed market economy countries was 2,986 it was 91 in Africa, 115 in Asia and 251 in Latin America.[15]

27. Second, even where such capabilities exist they are rarely employed in the task of upgrading indigenous techniques of production or adapting imported technology to local conditions. The current emphasis on export-oriented manufacturing that seeks to match international product standards and a persistent belief on the part of national decisionmakers and foreign advisors that capital-intensive techniques and frontier technologies are required to do so, are further disincentives to the development of indigenous technological capabilities. The exceedingly small machine-building sector in the least developed countries (table 4) and its weak linkage to other productive activities is a consequence of these historic attitudes, their persistance and the kind of industrialization model that they support. This weakness, however, renders today more difficult the kind of problem identification and problem solving activities associated with the myriad number of small innovations that collectively increase productivity and create a potential for exports. The generation of new technology to suit the local environment and even the adaptation of existing technology to meet changes in competitive conditions world-wide are also slighted.

28. Third, shortfalls in export earnings, deteriorating terms of trade and declining private capital flows (see this chapter's second section below) have combined to increase the reliance of least developed countries on foreign aid for development in the present period. Although it is concessionary, much of the bilateral aid received by the LDCs is tied to the purchase of goods and services in the donor country. By requiring that recipients expend upward of two-thirds of the funds in the donor country, tied aid further weakens the linkages between domestic knowledge or machinery producing capabilities and final goods producing activities. Insteading of complementing existing capabilities, tied aid thus crowds out initiatives and opportunities for indigenous technology capability building and it diminishes the possibilities for intra-developing country trade in technology.

5. *The impact of traditional structural adjustment programmes*

29. Structural adjustment programmes have done little to reduce the vulnerability, increase the stimulus for technological development and change coming from the demand side or improve the endogenous supply of technology in least developed countries. Indeed, there are some grounds to argue that in their design and application through error or omission, structural adjustment programmes have exacerbated the structural weaknesses of LDCs with respect to technology absorption, utilization and generation. The problem begins, as a recent meeting of governmental experts from donor countries and the least developed countries noted with the fact that "(i) in many cases, the peoples of the LDCs had not participated adequately in the decision-making processes at all levels."[16]

30. With regard to vulnerability, the 1980s have been dismal years for the least developed countries. Deindustrialization, reflected in the declining share of manufacturing in Gross Domestic Product from a high of 8.5 per cent in 1975 to 7.6 per cent in 1987 (table 3) suggests a narrowing of the economic base rather than its diversification. So, too, does the growing con-

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[14] IBRD, **World Development Report 1989**, Table 29, p. 220.

[15] UNCTAD, **Trade and Development Report, 1987**, Table 26, p. 79.

[16] United Nations, General Assembly, Meeting of Governmental Experts of Donor Countries and Multilateral and Bilateral Financial and Technical Assistance Institutions with Representatives of the Least Developed Countries, Second United Nations Conference on the Least Developed Countries, Preparatory Process for the Conference, Statement by the Chairman, A/CONF.147/DR/L.2, 30 May 1989, p. 5.

centration of exports as reflected in the rising share of three major products as a percentage of total exports of goods in 17 of the 20 LDCs reported in figure 1. Since these, moreover, are frequently commodities for which international markets are growing slowly or are under pressure from synthetic substitutes, the need to invest in the indigenous technological capabilities to increase productivity and hence the competitiveness of these products, to diversify the economy and to sustain a process of continuous adaptation and adjustment within it, is paramount.

31. Yet, macro-economic shocks stemming from falling export prices, austerity measures aimed at restoring external balances and ensuring fiscal and monetary discipline[17] and natural calamities - drought in parts of Africa, floods, droughts and cyclones in Bangladesh - have created a scissor effect on technology acquisition, absorption, utilization and development. On the demand side domestic purchasing power has shrunk, credit is in short supply, especially for small and medium sized enterprises and foreign exchange for the purchase of spare parts and intermediate goods needed to rehabilitate existing factories and increase productivity in both the agricultural and manufacturing sectors is limited. As the ILO has thus concluded:[18]

> Despite several years of structural adjustment programmes, including reduction in government expenditure, price reforms and devaluations, the hoped-for turnaround in agricultural exports has not materialised while the plight of the vulnerable groups has worsened, often as a result of these programmes. Most of these countries have experienced such a massive deterioration of the infrastructure that remunerative prices alone will not remain the main constraint to increased production. In the meantime, rising food prices (through removal of subsidies) and imports (through devaluation) have further hurt the urban and rural poor as well as the wage-earning classes.

32. On the supply side, cuts in public expenditure, usually an important feature of structural adjustment programmes, have adversely affected education and the few research, development and engineering capabilities that have been developed in these countries. In Burkina Faso, for example, the country's two national research institutes were facing financial difficulties in carrying out their research programmes as was the Government's plan to create a better technology information service that could support the technological upgrading of small and medium enterprises. In Niger:

> Priority areas of research included the development of new agricultural varieties adapted to the given environmental conditions; prototype development to promote the commercial utilization of solar energy; and the development of pharmaceutical products, particularly those based on traditional medicines. All these efforts were seriously constrained by the unfavourable geographic position of the country (land-locked and drought-stricken), the smallness of the domestic market, insufficient human and financial resources.[19]

33. In several other least developed countries, the substitution of biotechnologically engineered products and new materials for natural materials already poses a threat to many of their commodity exports. Neither the technological capabilities nor the financial resources, however, are available to permit these countries to keep abreast of these new technological challenges.

34. In the following we examine the failure of the substantial new programme of action to arrest the downward slide of the least developed countries during the 1980s focussing in the next section on technology flows to the least developed countries and in chapter II on case studies in technological choice, technology transfer and technology adaptation, utilization and development.

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[17] UNCTAD, The Least Developed Countries 1988 Report, pp. 5-35.

[18] United Nations, General Assembly, Meeting of Governmental Experts of Donor Countries and Multilateral and Bilateral Financial and Technical Assistance Institutions with Representatives of the Least Developed Countries, Second United Nations Conference on the Least Developed Countries, Preparatory Process for the Conference, "Note on the ILO's contribution to the Preparation for the Second United Nations Conference on the Least Developed Countries in 1990", A CONF 147 DR 3 Add.8, 13 March 1989, p. 3.

[19] UNIDO, "Expert Group Meeting on Prospects for Industrialization Policies in Developing Countries Taking into Account the Impact of Developments in the Field of New and High Technologies", Report, PPD. 118 (Spec.) 24 May 1989, pp. 5-7.

B. Changes in technology flows to the least developed countries

35. Technology consists in both the set of knowledge capabilities - including research and development, design, engineering, management, marketing, maintenance and production skills - and the machinery, tools and equipment through which production is carried out. The fact that technology includes both embodied and disembodied elements makes its measurement difficult but not impossible. Three variables have generally been accepted as proxies for technology flows. Commercial flows of technology are captured by traditional and new forms of foreign direct investment such as licensing agreements and management contracts[20] and by international trade in capital goods. More concessionary flows of technology are recorded in the technical assistance portions of bilateral and multilateral aid.

1. Foreign direct investment to the LDCs

36. Both push and pull factors have operated to shrink capital flows to the developing countries during the 1980s (table 5). The onset of the debt crisis and poor economic conditions lowered the profitability of existing foreign - owned companies in these countries and diminished the funds available for further investment. Depressed commodity markets led to the indefinite postponement of decisions to invest in the extractive sector which is central to the economies of many developing countries. Whereas shrinking domestic markets made further investment in import reproducing manufacturing activities less attractive in these countries, a shift of foreign investor interest towards services as distinct from manufacturing and extractive sectors has favored a disproportionately greater flow of new foreign investment to developed market-economy countries. This has been reinforced by the threat of increased protectionism and rising interest rates in the United States, the strengthening of the yen and the opening of the European Community market projected for 1992. Over the past decade these changes have transformed the United States from the world's major capital exporting country into the principal host country for foreign investment, have led to the emergence of Japan as a major capital exporting country and have intensified the flow of foreign investment into the countries of Western Europe. In the late 1960s and early 1970s, international trade pressures began to intensify but few technological innovations were then available to significantly alter the quantity or relative share of factor inputs and thereby reducing production costs. During this period, investors from the United States and a small number of European countries thus began to seek out low wage sites for export-oriented manufacturing activities that involved the production of labour-intensive goods requiring relatively simple technologies (clothing, shoes, toys, simple consumer electronics).

37. Recent technological changes of both an organizational and technical nature, however, have made labour costs less decisive as a factor in determining the location of foreign investment. In some industries, the introduction of highly automated manufacturing processes has made repatriation of industries to the DMECs more attractive. In other instances, while the use of more sophisticated technology to produce more complex products for regional export or for export to markets in the DMECs, has not led to repatriation, it has induced the relocation of these industries to those developing countries with specific competitive advantages. These advantages derive from the particular characteristics of the new production processes, notably the growing need for proximity to a substantial local network of services - maintenance and repairs, engineering capabilities, software specialists, communications linkages - to parts suppliers and frequently to clients, especially where products are custom designed as in the machinery and information technologies sectors or even in the clothing industry. Production of these more knowledge-intensive products, moreover, requires higher levels of literacy and training than is usually found in the developing countries.[21]

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[20] Insofar as the least developed countries are concerned licensing agreements are of very recent origins but management contracts are widely used, especially in state-owned enterprises. All too frequently, however, such contracts contain no provision for training or the transfer of know-how. See the case studies in Chapter II, as well as UNCTAD, **Transfert et développement de la technologie au Togo** (UNCTAD TT 82), 1986 and UNCTAD, **Transfer and Development of Technology in Nepal. Policy and Institutional Issues**(UNCTAD TT 80), 1985.

[21] For a more detailed discussion of the effect of these changes on investment in the developing countries see UNCTAD, **Trade and Development Report, 1987** especially Annex 1 "Case Studies on Technology and Competitiveness in Selected Industries" pp. 137-160, Lynn K. Mytelka "The Textile and Clothing Industry: A Point paper" prepared for the OECD Development Center project on New Technologies and Trade (Paris: June 1988); M. Castells "High Technology, World Development and Structural Transformation: The Trends and the Debate" in **Alternatives**, Vol. 11 (1986); Raphael Kaplinsky, "The International Context for Industrialization in the Coming Decade", **Journal of Development Studies (1984)**, Juan Rada "Information Technology and the Third World" in T. Forester (ed.) **The Infor-**

38. Whereas initially the constellation of factors affecting the foreign investment decision-making process favoured the flow of new foreign direct investment into the developing countries, changing production requirements and competitive conditions since the mid-1970s, have begun to marginalize many of the developing countries from the main flows of technology that are channelled through foreign direct investment. The ratio of foreign direct investment flows into the developing countries to inflows of FDI in the developed market-economy countries which averaged .253 in the first period and rose to a high of 1980 before climbing steeply in 1981 and 1982 as a result of massive investments in Saudi Arabia in those two years. This investment, however, was not indicative of a new upward trend as the ratio once again declined, falling below the 1960s average by 1986 (table 5). The least developed countries, because of their particular structural weaknesses, are faring even less well.

39. During the 1980s many of the LDCs liberalized foreign investment policies, streamlined and rendered more transparent foreign investment procedures and signed bilateral investment promotion and protection treaties.[22] Despite policy changes such as these that under earlier conditions might have made the LDCs more attractive to foreign investors, actual recorded flows have been small and diminishing both absolutely and relative to similar flows to other developing countries. In current US dollars, FDI flows to the least developed countries fell from an annual average of $288 million during the biennium 1980-1981 to an annual average of $136.5 in 1985 and 1986 (table 5). The LDC share in the flow of foreign direct investment to all developing countries, which had risen from an annual average of 2 per cent in the period from 1965-1972 to 3.3 per cent in the period 1973-1980, fell dramatically in the 1980s to an annual average of only .9 per cent (table 5). This FDI flow, moreover, accounted for only a tiny share of all external financial flows going to the least developed countries in the 1980s. Even then, such flows as have occurred, were largely concentrated in only a few of the LDCs (table 6).

2. Imports of capital goods into the LDCs

40. Many of the developing countries experienced a fall in their export earnings due to deteriorating terms of trade and a decline or reversal of capital inflows. As a consequence, the imports of capital goods and payments of royalties and fees to developed market - economy country firms, which are closely associated with such imports, point to stagnation and retrogression.[23] A recent study by the UNCTAD secretariat sheds some light on the factors which contributed to the fall in capital goods imports. Of the 53 developing countries covered in this study, however, only 11 were least developed - Central African Republic, Democratic Yemen, Ethiopia, Gambia, Mali, Niger, Rwanda, Somalia, Sudan, Togo, Uganda. Although the sample is small and excludes most of the Asian LDCs, it, nevertheless, points to a number of changes currently underway and their consequences for technological development in these countries.

41. During the 1980s virtually none of the developing countries have been able to sustain the rate of growth of capital goods imports that had been achieved in the preceeding decade. The slow down of capital goods inflows is the outcome of a combination of factors discussed in section I above notably price fluctuations for exports, high debt servicing charges and the overall deterioration of the external environment. The impact of these factors on capital goods imports and other commercial types of technology-related flows can be seen in the deterioration in what is a very small capacity to import in the least developed countries even when compared to other developing countries.[24] During the 1970s, import capacity in the LDCs was already growing more slowly than in other developing countries and during the 1980s it declined in both absolute and relative terms (table 7).

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mation Technology revolution (Oxford: Blackwell, 1985), pp. 571-589; Dan Jones and James Womack "Freeway 2000: The Hard Road South" in **South** (november 1984), pp. 69-71 and Wilfried Lutkenhorst "Challenges from New Trends in Foreign Investment" **Intereconomics** (September October 1988), pp. 220-227.

[22] For details see General Assembly, Second United Nations Conference on the Least Developed Countries, Preparatory Process for the Conference "Role of Transnational Corporations in the Least Developed Countries" contribution by the UN Centre on Transnational Corporations, Doc. No. A Conf 147 DR 3 Add.9 (13 March 1989), pp. 13-19 and UNCTAD, **The Least Developed Countries 1988 Report**, p. 21.

[23] See UNCTAD, **Recent trends in international technology flows and their implications for development**. 1988 (TD B C.6 145).

[24] "The capacity to export may be defined from balance of payments accounts as the sum total of receipts of exports of goods, balance on services (including interest and direct investment income payments), balance of government and private transfers, net long-term capital and a correction factor for errors and ommissions". UNCTAD, **Recent Trends in International Technology Flows and their Implications for Development** TD B C.6 145 (18 August 1988), p.13.

Table 5
Inflows of direct investment into the developing countries and the developed market economy countries: 1965-1986

(millions of current US dollars)

	1965	1966	1967	1968	1969	1970	1971	1972
DCs	529	563	1189	1547	2135	1999	2397	1704
East Asia	116	58	113	110	203	354	436	633
LDCs (a)	6	2	28	45	64	43	30	48
DMECs	2306	2435	5014	5225	6285	8701	8619	9224
US	410	420	700	810	1260	1460	361	955
EC-10	698	674	2760	2587	3020	4564	5189	5696
Japan	50	30	40	80	70	90	211	163
					RATIOS			
DC/DMEC	.229	.231	.237	.296	.340	.230	.278	.185
LDC/oth.DC	.011	.004	.024	.030	.031	.022	.013	.029
	1973	**1974**	**1975**	**1976**	**1977**	**1978**	**1979**	**1980**
DCs	4165	209	8423	4354	6408	8373	9804	7539
East Asia	802	1168	1511	1410	1486	1592	2135	2841
LDCs	94	82	-51	113	111	280	429	344
DMECs	13435	20586	14520	13731	18513	24592	32766	41044
USA	2813	4762	2635	4341	3724	7900	11861	16907
EC-10	8850	11750	9649	7554	11483	12952	16700	20821
Japan	-36	204	231	116	23	13	246	286
					RATIOS			
DC/DMEC	.310	.010	.580	.317	.346	.341	.300	.184
LDC/oth.DC	.023	.650	.006	.027	.018	.035	.045	.048
	1981	**1982**	**1983**	**1984**	**1985**	**1986**		
DCs	20668 [b]	24657 [b]	14283	14726	10915	10830		
East Asia	4582	4008	3803	3340	2360	3332		
LDCs	231	184	74	111	133	140		
DMECs	42058	29899	33627	37629	35159	51453		
USA	25411	13877	11973	25349	19170	24684		
EC-10	15660	13733	15031	7730	14148	19096		
Japan	189	442	506	-10	630	235		
					RATIOS			
DC/DMEC	.491	.825	.425	.391	.310	.210		
LDC/oth.DC	.011	.008	.005	.008	.012	.013		

Source: UNCTAD secretariat computations based on data from OECD and IMF.

a Excluding Afghanistan, Cape Verde, Comoros, Dem.Yemen, Djibouti, Equatorial Guinea, Laos People's Democratic Rep., Maldives, Myanmar, Nepal, Samoa or Tuvalu.

b West Asia received $5934 million in 1981 and $11,514 million in 1982 much of which went to Saudi Arabia.

Table 6

Inflow of foreign direct investment into the least developed countries by country: 1980-1986

(millions of US dollars at current prices)

Country	1980	1981	1982	1983	1984	1985	1986
Afghanistan	9.0	0.2	0.1	..	..	..	..
Bangladesh	8.5	5.4	7.0	1.1	3.8	-6.7	-1.1
Benin	4.3	2.1	..	..	..	..	..
Bhutan	..	..	..	..	..	..	..
Botswana	111.5	88.4	21.1	23.8	62.1	53.6	90.5
Burkina Faso	..	2.5	2.0	2.0	1.6	..	..
Burundi	4.6	11.1	0.9	3.0	1.2	0.2	0.3
Cape Verde	..	..	..	..	..	..	..
Central African Republic	5.3	5.8	9.2	4.5	5.1	2.9	8.2
Chad	..	..	..	..	9.2	53.6	28.2
Comoros	..	..	0.2	..	..	..	..
Democratic Yemen	..	0.5	..	..	..	..	..
Djibouti	0.2	..	-0.1	..	0.2	0.2	1.2
Equatorial Guinea	..	-0.2	0.5	0.5	2.2	..	..
Ethiopia	..	..	..	..	..	..	..
Gambia	0.3	0.7	0.3	-0.4	-1.7	-0.5	..
Guinea	0.6	-1.3	..	0.4	0.7	1.1	4.0
Guinea-Bissau	..	..	..	..	2.3	1.4	0.8
Haiti	13.0	8.1	7.0	8.3	4.4	5.0	4.9
Kiribati	..	..	..	..	..	..	..
Lao People's Democratic Republic	..	..	..	..	..	-1.6	..
Lesotho	4.6	4.8	3.1	4.8	2.4	4.8	2.1
Malawi	9.5	1.1	..	2.6	..	0.5	..
Maldives	-0.1	..	-2.9	0.2	-0.1	..	..
Mali	2.3	3.7	1.5	3.1	4.1	4.5	4.3
Mauritania	27.1	12.5	15.0	1.4	8.5	7.0	4.5
Myanmar	0.4	..	..	-0.4	0.8	..	..
Nepal	0.3	-0.2	..	-0.6	1.0	0.7	1.2
Niger	49.1	-6.1	28.3	1.2	1.4	1.2	1.2
Rwanda	16.4	18.0	20.8	11.1	15.1	14.6	17.6
Samoa	..	..	..	-0.1	..	0.4	-0.2
Sao Tome and Principe	..	..	..	..	..	..	..
Sierra Leone	-18.6	7.5	4.6	1.7	5.8	-3.8	-6.5
Somalia	..	..	-0.8	-8.2	-15.0	-0.7	-0.1
Sudan	..	..	..	..	8.8	-2.8	..
Tuvalu	..	..	..	..	..	..	..
Togo	42.3	10.1	16.1	1.5	-9.9	..	..
Uganda	4.0	..	2.0	..	..	-4.0	..
United Republic of Tanzania	4.0	18.9	17.3	1.5	-8.4	14.5	3.3
Vanuatu	..	..	7.0	5.9	7.6	4.6	2.0
Yemen	-1.2	13.8	51.8	15.8	0.1	2.1	4.2

Source: United Nations Centre on Transnational Corporations, based on IMF Balance of Payments Tape of November 1988 and reported in UN General Assembly (1989), p. 5.

Table 7

Import capacity in a sample of developing and least developed countries

(millions of current US dollars and percentage change over the previous period)

	1970/ 1972	1973/ 1975	1976/ 1978	1979/ 1981	1982/ 1985	1985/ 1986
11 LDCs [a]						
avg.annual amounts						
in millions of US $	1022	1737	2723	4176	3939	3864
% change	-	+ 70	+ 57	+ 53	- 6	- 2
53 DCs						
avg.annual amounts						
in millions of US $	36772	86598	140718	235837	231129	217118
% change	-	+ 135	+ 62	+ 68	- 2	- 6

Source: UNCTAD secretariat computations based on data from the United Nations and other international sources.

[a] Central African Republic, Democratic Yemen, Ethiopia, Gambia, Mali, Niger, Rwanda, Somalia, Sudan, Togo, Uganda.

42. Changes in the main components of the capacity to import are also revealing, especially with respect to their contrasting incidence between the least developed and other developing countries. Table 8, for example, shows that a large part of the declining capacity to import in the LDCs during the 1980s resulted from declining terms of trade as reflected in the variable "export of goods". For other developing countries, the debt crisis, as represented by the balance on long-term capital, was a far more important factor.

43. Tables 8 and 9 also point to another distinguishing feature of the LDC's situation, the role that foreign aid, as reflected in the variable "balance on transfers" has played in maintaining the import capacity of the least developed countries. Despite this, table 9, however, reveals that the impact of declining import capacity nonetheless has hit the imports of capital goods into LDCs particularly hard. Whereas the capacity to import declined 18 per cent for all 53 developing countries and only 11 per cent for the least developing countries, the effect has been to reduce the already tiny flow of capital goods imports into the least developed countries nearly as much as in other developing countries. This has occurred, as the ratios of capital goods imports to total imports demonstrate, primarily because of the inability to maintain technology-related imports in the LDCs by further compressing imports of basic foodstuffs, fuel and the raw materials needed to keep existing production units in operation and to prevent the collapse of an already unacceptably low living standard.

3. *Technical assistance flows to the LDCs*

44. Whereas in many of the developing countries commercial technology flows predominate, for the least developed countries, the major sources of technology inflows consist of technical assistance and the purchase of capital goods, engineering, management and other services with funds provided through official development assistance. In the case of Tanzania, for example, much of the resource shortfall resulting from a current account deficit of $800 million will have to be made up through concessionary aid. "Only with donor funding for essential items such as spareparts and machinery can the Government hope to sustain a small but steady growth in imports from $1.2 bn in 1987-1988 to $1.4 bn in 1992-1993.[25]

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[25] Financial Times, April 25, 1989.

Table 8

Factors [a] affecting changes in the capacity to import in a sample of developing and least developed countries

(in percentages)

	Change in capacity to import	Resulting from changes in:			
		Exports of goods	Long-term capital	Balance on services [b]	Transfers
53 DCs	-18	-11	-19	+3	+ 9
11 LDCs	-11	-13	-11	-1	+14

Source: UNCTAD secretariat computations based on data from the United Nations and other international sources.

[a] Changes in capacity to import by its major components: 1981-1986 as a percentage of the capacity to import in 1981.

[b] Includes errors.

Table 9

Technology imports and macro-economic performance in a sample of developing and least developed countries

(in percentages)

	Capital goods imports		Capacity to import		Ratio of capital goods imports to total imports			
	1970/ 1981	1981/ 1986	1970/ 1981	1981 1986	1970	1975	1980	1986
53 DCs	22.6	-2.1	23.0	-4.0	37	39	41	39
11 LDCs	20.9	-2.0	17.0	-2.4	27	44	39	27

Source: UNCTAD Secretariat computations based on data from the United Nations and other international sources.

45. Since the adoption of the Substantial New Programme of Action, therefore, donors have been urged to increase concessionary aid to the least developed countries, speed disbursement of funds and focus programme and project aid on activities highlighted in the SNPA, particularly those related to production. Specific measures to orient and monitor progress towards these goals, however, were lacking and this, among other factors, has contributed to the relatively slow growth of net resources to the LDCs. Indeed, the limited gains that have occurred in the Indicative Planning Figures (IPFs) for the 3rd (1982-1986) and fourth (1987-1991) UNDP programming cycles, UNDP figures show, results largely from the creation of two supplementary allocations to the basic resource allocation, one for particular geographic or economic handicaps in specific LDCs and another based on the assignment of three "supplmenetary points" to each LDC. These measures have "increased the total IPF allocation to the 42 LDCs by an estimated $283 million for the fourth programming cycle which is a gross increase averaging about 25 per cent per LDC...".[26]

46. Data from other sources, and with reference to specific geographical regions or sectoral programmes, however, suggest that this is still insufficient. ODA Commitments from DAC member countries and multilateral agencies to individual LDCs for productive activities such as industry, mining and construction, for example, averaged as low as 2.4 per cent of total ODA commitment over the years 1983-1985. Education and training which are the backbone of efficient production, and flexible adjustment and constitute one of the primary mechanisms for the building of indigenous technological capabilities received only 3.6 per cent of the ODA commitments in this period.[27] While technical co-operation and other unallocated commitments accounted for 32.4 per cent of all flows in this period, a detailed look at official technical assistance per country from 1970-1987 with particular attention to the 1980s shows that such flows stagnated or deteriorated in 18 of the 42 countries. Of total technical co-operation grants to the LDCs in 1986 amounting to US $2166.14 million, 43.7 per cent was, moreover, concentrated in only a few least developed countries - Bangladesh, Ethiopia, Tanzania, Sudan, Somalia, Burkina Faso, Niger and Mali. The following year these countries, with Benin replacing Mali, increased their share of all technical co-operation grants to 46.9 per cent. From a country perspective, the share of technical co-operation grants in total ODA exceeded 35 per cent in seven, mainly small LDCs - Vanuatu, Tuvalu, Lao Peoples Dem. Rep., Kiribati, Djibouti, Equatorial Guinea and Afghanistan. Given the primary role that technical assistance plays among the three major sources of technology flows into the LDCs, and the importance assigned to the building of indigenous technological capabilities in the SNPA, these results are also disappointing.

47. With respect to overall resources the situation of Africa within the group of least developed countries is particularly disturbing. Recent calculations by the United Nations Secretariat for the Advisory Group on Financial Flows for Africa showed that new credit flows in 1985-1987 were actually $2.4 billion lower than during the period 1979-1981.[28] The Conference of Ministers of African LDCs at its ninth meeting, moreover, pointed out that:[29]

> In 1981 the total cost of country development projects and programmes presented by 21 African LDCs at the Paris Conference was $US 133 billion (1980 prices) for the period 1981-1990, 60 per cent of which or $US 81 billion was made up of their external funding requirements. With the addition of five more African countries in 1982, ECA's provisional estimate of the external financing needed to support the SNPA in the 26 LDCs was $US 96.5 billion or an annual flow of at least $US 8.6 billion. Including resource flows to Mozambique and Mauritania recently listed as LDCs, total net financial flows averaged about $US 4.97 billion during 1981-1987 which falls far short of the annual minimu external assistance required to transform substantially the LDC economies.

48. There thus remains a considerable resource gap in the LDCs. To fully appreciate the extensiveness of this gap an analysis of how aid is used and with what results for technological development and change will be presented in chapter II.

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[26] U.N., General Assembly, Second United Nations Conference on the Least Developed Countries preparatory process for the Conference "Development in the 1980s and Proposals for the 1990s" contribution by the United Nations Development Programme, A CONF 147 DR 3 Add.10 (13 March 1989), p. 3-4.

[27] See: U.N., General Assembly, Second United Nations Conference on the Least Developed Countries preparatory process for the conference "A review of the Manufacturing Sector in the Least Developed Countries - The Implementation of SNPA in the Eighties and Proposals for Further Action" Contribution by United Nations Industrial Development Organization", A CONF 147 DR 3 Add.3 (10 March 1989), p. 35.

[28] U.N., General Assembly, Second United Nations Conference on the Least Developed Countries preparatory process for the Conference "A review of the Manufacturing Sector in the Least Developed Countries - The Implementation of SNPA in the Eighties and Proposals for Further Action" Contribution by the United Nations Industrial Development Organization", A CONF 147 DR 3 Add.3 (10 March 1989), p. 8.

[29] Declaration by the Conference of Ministers of African LDCs at its Nineth Meeting, Addis Ababa, 4-5 April 1989.

4. South-South technology flows

49. If North-South technology flows to the LDCs have not met the expectations expressed in the SNPA, the debt crisis and the fall in oil prices have seriously curtailed South-South technology flows. For the most part, such flows have stagnated during the 1980s and in some instances declined.

50. As pointed out above, overall foreign direct investment plays only a minor role in technology flows to the least developed countries. However, in at least one of these countries, Bangladesh, foreign direct investment from other developing countries has been of some importance, particularly in stimulating further the development of technological capabilities in the textile and clothing industry as the case study in chapter II reveals. While there may be some scope for increased technology flows to the LDCs through foreign investment from the developing countries, it is unlikely that this will significantly change the LDCs' situation with respect to foreign direct investment since only a small number of South and East Asian countries are likely to become capital exporters in the medium term. Historically, first-time investors have tended to invest in neighbouring countries. The organizational and technological changes already discussed, moreover, are likely to reinforce this pattern.

51. Data on technology-related trade between developing countries and the least developed countries are also unavailable but a number of proxies can be used to arrive at an assessment of such flows since the mid-1970s when some eight developing economies - Argentina, Brazil and Mexico in "developing America" and Republic of Korea, Singapore, Malaysia, Hong Kong and Thailand in "South and South-East Asia" - began to export machinery and equipment (SITC 7). The share of capital goods exports from "developing America" to other developing countries, for example, rose steadily from a low of 5.1 per cent of total non-fuel exports to the developing world in 1965 to a high of 19.4 per cent in 1980 and then declined below its 1975 figure to 16.3 per cent in 1985. The share of capital goods exports in total non-fuel exports to the developing countries coming from South and South-East Asia, on the other hand, continued its rise over the entire period, reaching 25.2 per cent in 1985. With regard to the least developed countries, although the value of South-East Asia's trade in machinery and equipment to Africa, which can serve as a proxy for the least developed countries, rose from $1,099 million in 1980 to $1,190 million in 1984, it then dropped dramatically to $807 million in 1985. Moreover, the share of total exports going to the DMECs has increased for a number of the most heavily indebted capital goods exporting developing countries, those with debt servicing payments in excess of 25 per cent of exports - Republic of Korea and Thailand in 1985 and 1986, Malaysia in 1985 and Argentina, Brazil and Mexico throughout much of the 1980s.[30] These data suggest that the debt crisis is having a powerful effect on the supply of technology-related goods to the least developed countries from other developing countries which are unable to extend the necessary export credits and must focus on exports to countries with convertible currencies. Deteriorating external conditions for the least developed countries have also contributed to their declining share in capital goods exports from other developing countries.

52. Falling international prices for oil combined with, in some cases, an increase in debt service has also had a negative impact on South-South official development assistance, notably from the OPEC member countries. Whereas in the early 1980s roughly 13 per cent of all bilateral and multilateral concessional aid to the least developed countries came from OPEC member countries, in the period 1984-1986 this fell to an annual average of 7.6 per cent. Net total bilateral concessional flows from OPEC member countries to the least developed countries fell in absolute terms from an average of $884.3 million per year in the period 1980-1983 to an annual average of $347.87 million in the years 1984-1986.[31]

53. In sum, much of the progress recorded in the development of South-South technology flows in the late 1970s and early 1980s has been seriously compromised by the debt crisis and deteriorating external conditions for all developing countries. More than simple exhortations to increase resource flows to the developing countries will be required to reverse this situation.

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[30] Calculated from table 5 of UN, General Assembly, Second United Nations Conference on the Least Developed Countries preparatory process for the Conference, "Development in the 1980s and Proposals for the 1990s" Contribution by the United Nations Development Programme, A/CONF.147/DR/3/Add.10 (13 March 1989).

[31] The figures in this paragraph were calculated by the UNCTAD secretariat based on United Nations Trade Data.

Chapter II

TECHNOLOGY ACQUISITION, UTILIZATION, ABSORPTION AND GENERATION IN THE LEAST DEVELOPED COUNTRIES

54. A large proportion of the population in the least developed countries are dependent upon production techniques that are incapable of generating a level of income sufficient for their most elemental needs. As older solutions prove ineffective and the economic crisis shrinks financial resources, it has become imperative to develop new ways of thinking about and dealing with this situation.

55. The conceptual framework presented here seeks to stimulate this process by taking as its point of departure the distinctions drawn in chapter I between an import substitution and an import reproduction model and extending them beyond the manufacturing sector to agriculture, energy, training and services. It outlines many of the key technological capabilities needed for sustained growth, structural transformation and continuous adjustment (figure 3). These capabilities are broken down along three dimensions - product-related, process-related and organizational technologies and their mastery is charted through four phases - acquisition, utilization, absorption and innovation. From this perspective it is clear that the process of technological development consists in either building these indigenous capabilities within a producing unit or in developing them through linkages between a given producing unit and public sector bodies, industry associations, universities, R and D institutions or other producing units.

56. Thirteen case studies have been chosen to illustrate this framework. These cases draw upon material from a representative grouping of eight least developed countries - Bangladesh, Nepal and Tuvalu from Asia; Tanzania, Rwanda, Togo, Benin and Sierra Leone from Africa (figure 4). They cover raw material and food processing, several of the basic industries found in the least developed countries and a number of agricultural sectors, service and training activities. Both success stories and less successful endeavors are included.

57. Collectively this set of case studies challenges many of the established ideas that remain an implict force in contemporary technology policy-making. The first is the persistant belief that the peasants and artisans who people this world of poverty and low productivity techniques are part of a stagnating "traditional" society.[32] Implicit in this proposition is the notion that peasant agriculture cannot be transformed and must therefore be replaced by "modern" farming techniques and land holding patterns. Peasant knowledge of farming techniques is thus devalued and peasants, especially women who play a major role in food production and processing in most least developed countries, are rarely consulted in the design or implementation of rural development schemes that involve a change in planting rhythms, crops, or the use of inputs. The negative effects on the development of the local skill base including linkages to domestic manufacturing activities and the limited sustainability of such technological changes as reflected in the pattern of productivity growth are brought out in two of the cases discussed here - the adoption of steel rice hullers in Bangladesh and the introduction of improved fruit tree and livestock in Nepal. Unless specific action to remedy this is not taken, current plans to rehabilitate the National Milling Corporation in Tanzania, under the sponsorship of foreign financing agencies, moreover, may replicate this negative model once again.

58. This view of a stagnant peasant economy also applies to the artisans who work within it. Metalworkers, weavers and potters have been systematically excluded from consideration as a possible source for the development of innovative forms of "modern" industry. Few efforts have been made to train artisans in new technological or managerial skills . Funds for research to improve the quality of artisanal products and the efficiency of small scale production techniques are

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[32] This discussion draws on Lynn K. Mytelka "The Unfulfilled Promise of African Industrialization" plenary address to the American African Studies Association (Chicago: 28-31 October 1988), to be published in the African Studies Review, December 1989.

scarce and where available have often been used unsuccessfully in a top-down fashion to impose an externally generated "solution". Two of the more innovative efforts to reverse this process are the ILO's programme to help local small-scale urban producers in Rwanda organize themselves and develop the capability to identify problems, secure access to production resources and acquire occupational skills and the successful development of a rural financing scheme for the landless in Bangladesh, the Grameen Bank.

59. A second myth challenged by these case studies is that of technological leapfrogging. The belief that developing countries can take advantage of successive waves of new technology to leapfrog assumes away the incrementalism that has historically characterized the building of indigenous technological capabilities: by implicitly placing the emphasis on the transfer of productive capacity rather than on the transfer of "know-how" and "know-why", the literature on leapfrogging rarely expresses a concern with the central mastery of skills required for technology absorption (figure 3). Yet Bangladesh's experience in the textile industry reviewed here, demonstrates how long process of technological mastery takes and how important it is as a basis for further rapid technological change. The counter examples, illustrated by the pyrethrum processing and cement cases demonstrate that little time may actually be saved and the costs of failure can be quite high when leapfrogging in inadequate conditions is attempted.

60. Although the complexity of the technology relative to its new environment determines the size of the gap over which the leap must be made and this may change with each specific case, at a minimum successful leapfrogging requires massive concommitant investment in education,in research and development and in training. Only through such investment is it possible to build the organizational, scientific and engineering capacities within Governments and among producers "to assess and select applications conducive to leapfrogging", to adapt these new technologies to local conditions, to assimilate and efficiently utilize them, to diffuse them widely and eventually to develop new products and processes through further innovation. The lack of financial resources and the low level of education currently found in the least developed countries make technological leapfrogging particularly problematic as the current difficulties encountered in training seamen in Tuvalu show. Nonetheless, a *selective approach* in the use of "frontier" technologies can produce positive results as the tea cloning example in Malawi illustrates.

61. The third challenge presented by these case studies is to the assumption common in much of the conventional economic literature[33] that any increment to productive capacity resulting from the import of foreign capital or machinery is a technology transfer. As the case studies of cement production and pyrethrum processing illustrate, learning to operate an imported machine does not necessarily provide the user with the ability to maintain or reproduce the technology embodied in that machine nor modify, improve or extend it in response to changing costs, tastes or competitive conditions. Recent research on productivity changes in developing countries, moreover, puts into question the extent to which within that context, changes in efficiency are an automatic consequence of participation in the production process.[34] This research and the case studies presented here suggest that at the micro-economic level, a *deliberate* effort to master technology is required. At the macro-economic level diffusion of technology among producing units and from research

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[33] A.S. Bhalla & D. James "Some Conceptual and Policy Issues" in A.S. Bhalla & D. James (eds.) New Technologies and Development Experiences in "Technology Blending" (Boulder: Colo., Lynne Reiner, 1988), pp. 28-50, p. 34. For a longer discussion of the problems encountered with leapfrogging in current African rehabilitation strategies see Lynn K. Myltelka "Building indigenous technological capacity in Ivorian industry" paper prepared for a presentation to the conference on "Alternative Industrialization Strategies for Africa" (Oxford University: 13-15 December 1989). With regard to leapfrogging and the NICs see Dieter Ernst & David O'Connor, *New Technologies, Global Competition and Latecomer Industrialization - an Agenda for the 1990s* (Paris: OECD Development Center, 1989).

[34] Earlier analyses of the process of technological mastery within industrial firms attributed increases in labour productivity over time or decreases in unit costs to the automatic effect of what Arrow called "learning-by-doing", that is, learning in the course of production (K. Arrow, "The economic Implications of Learning by Doing" Review of Economic Studies, 1962, 29, pp. 15-72; P. David "The Horndahl Effect" in Lowell, 1834-56: A Shortrun Learning Curve for Integrated Cotton Textile Mills," in P.A. David, **Technical Choice, Innovation and Economic Growth** Cambridge: Cambridge University Press 1975) and S. Hollander, **The Sources of Increased Efficiency:** A Study of Dupont Rayon Plants (Cambridge, MA: MIT Press, 1964). In contrast, more recent work on a variety of firms in the developing countries has shown sharp declines in operating efficiency and in labour productivity over time Ahmed, Q. "Accumulation of technological capability and assimilation of imported industrial production systems in the cotton textile industry in Bangladesh" in Absorption and diffusion of imported technology, proceedings of a workshop held in Singapore, 26-30 January 1981 (Ottawa: International Development Research Centre, 1983) pp. 21-27. M. Bell and K. Hoffman, Industrial Development with Imported Technology: A Strategic Perspective on Policy (Brighton: University of Sussex, SPRU, 1981); M. Bell, D. Scott-Kemimis and W. Satyarakwit, Learning and Technical Change in the Development of Manufacturing Industry: A Case Study of a Permanently Infant Enterprise (Sussex: SPRU, March 1980); N.P. Girvan, **Technology Policies for Small Developing Countries:** A Study of the Caribbean (Mona: Institute of Social and Economic Research, University of the West Indies 1983) and Katz, J. and E. Ablin, (1978) From Infant Industry to Technology Exports: The Argentine Experience in the International Sale of Industrial Plants and Engineering Works (Buenos Aires: Inter-American Development Bank working paper No. 14, October).

institutes to producing units is also crucial, as the two hydroelectricity cases, the Sierra Leone engineering design and prototype development example, the tea cloning and the improved livestock and fruit tree cases demonstrate.

62. Yet learning-by-doing in this dynamic sense implies that the information acquired in the course of production is first, related to technological knowledge about the underlying process and second, that peasants, workers, technicians and managers are motivated to act upon that knowledge. It is this process that marks a move beyond the mastery of operating technology (the utilization phase) to the absorption of imported technology by the producing unit and the society within which it is embedded.

63. As seen in chapter I, the connection between problem identification and problem-solving, however, has both supply and demand side dimensions. On the supply side it presupposes either the building of indigenous technological capabilities within the firm through prior learning experiences and/or access to research and development facilities and funds outside the firm, as for example, in public agencies, university research institutes or supplier firms. In the former instance, trouble-shooting and resolving bottlenecks in product, process or organizational technologies have proven to be important means through which technological capabilities can be built within the firm.[35] With respect to the latter,as these case studies illustrate, the articulation between the sphere of research and that of production has been highly problematic.

64. On the demand side, stimuli for learning-by-doing in this dynamic sense must also be present. Such stimuli may come from any number of sources - changes in tastes, incomes, competition, availability of inputs or foreign exchange, government policies or other.[36] In the absence of such stimuli, however, there may be little incentive within the producing unit to reduce costs, increase productivity, improve product quality or expand output through the product, process or organizational changes that are the essence of technological mastery. How these factors interact is discussed more fully in the case studies presented below.

A. The manufacturing sector

65. Criticism of the mass production, import reproduction industrialization model mounted as the contradictions to which it gave rise became increasingly more apparent in the late 1970s and early 1980s. From a technology perspective, such criticism appears justified when directed at industrial misadventures such as the truck and automobile assembly plants that simply assemble vehicles from imported knocked-down kits. Both technological learning and domestic value added are limited in such ventures. When the capital is secured through foreign loans rather than equity, the resulting financial charges, moreover, tend to increase the already high foreign exchange costs of these projects. Imports of kits and spare parts and the high costs of assembling a relatively few units in a large number of models raises the price of these vehicles relative to imports and does so without any compensating benefit to consumers or to the economy more generally in terms of linkage or learning effects.[37]

66. The same, however, cannot be said for industries that process local raw materials for domestic consumption and for export or those that could serve a wider domestic market. In this section we examine six such cases - pyrethrum extraction and processing in Rwanda, two regional cement projects - CIMAO in Togo and the Onigbolo Cement plant in Benin - one national cement plant, la Cimenterie de Mashyuza in Rwanda, textiles in Bangladesh and maize milling in Tanzania. All of these cases involve the use of local raw materials. In the cement , textile and milling cases domestic consumption levels are largely sufficient to sustain local production.

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[35] C.J. Dahlman and L.E. Westphal "Technological Effort in Industrial Development - an interpretive survey of recent research" (Washington D.C. World Bank, July 1981); J. Katz and E. Ablin, From Infant Industry to Technology Exports: The Argentine Experience in the International Sale of Industrial Plants and Engineering Works (Buenos Aires: Inter-American Development Bank working paper No. 14, Oct. 1978); P. Maxwell, "Technical and Organization Change in Steel Plants: An Argentine and a Brazilian Case" paper presented at a Simposio de Análisis Organizacional (Buenos Aires, 16-18 Oct. 1980).

[36] N. Rosenberg, **Perspectives on Technology** (Cambridge: Cambridge University Press, 1976); F. Sagasti, "Underdevelopment, Science and Technology: The Point of View of the Underdeveloped Countries," Science Studies, 3 (1973), pp. 47-59 and P. Maxwell & M. Teubal, "Capacity-Stretching Technical Change: Some Empirical and Theoretical Aspects (IDB ECLA Research Programme on Scientific and Technological Development in Latin America, Working Paper No. 36, Nov. 1980), pp. 13-48.

[37] CEREM: 1986, Broden & Mattsson: 1989.

Textiles, moreover, are also being exported from Bangladesh. Pyrethrum, used in the manufacture of insecticides and pesticides, is mainly sold in international markets although natural pyrethrum is under direct pressure from synthetic substitutes - a factor that has compromised production and processing of several major agricultural commodities in the least developed countries.[38]

1. The acquisition phase: the case of pyrethrum processing[39]

67. To move from production to processing, for all that it is economically and techologically rewarding, is both a difficult and uncertain process. Difficult, because the financial gains from processing make the location of processing activities a desirable and frequently a contentious issue between major users and major producers. Bargaining and negotiation skills are vital here. Uncertain, because competition leads to the continuous introduction of substitutes - synthetics and more recently genetically engineered alternatives. Building indigenous evaluation, assessment and planning capabilities and linking these to independent sources of information on the global economy and on technological change in specific sectors are thus also needed as the following case study illustrates.

68. In the 1960s, pyrethrum was being cultivated by some 10,000 peasant families in the Gisenyi and Ruhengeri districts of Rwanda. A local co-operative operated the wood-fired ovens that dried the pyrethrum flowers for export. As fuel-wood became scarce the ovens were converted to oil and with the oil price rise to peat. From a technological perspective the oil crisis thus provided an unexpected inducement for technological change since conversion to peat required modifications to the drying process to reduce the excess heat generated by this new fuel. Use of peat also made possible a savings in foreign exchange but the cost of transporting peat to the pyrethrum growing region raised the energy cost of production over what it could have been had wood been available. By increasing domestic value added, further processing could potentially offset this additional cost.

69. The decision to move towards raw material processing was taken by the Rwandan Government in 1968 when it signed an agreement with a specialized agency for the construction of a pyrethrum processing plant. According to the terms of this agreement the plant would include both the extraction of pyrethrum from the dried flowers and its refining. In 1970, however, a decision was taken to divide the project into two stages with only the extraction plant to be built in the first phase.

70. Consultants were hired by the specialized agency to manage the project and organize the choice and procurement of machinery and equipment. USINEX began production of unrefined pyrethrun in 1972. As problems with the equipment emerged, the specialized agency's experts continued to manage the plant, paid for and undertook the necessary modifications.

71. Over the next several years a succession of project experts also undertook the feasibility studies and organized the tender for stage two. Neither the Rwandan Government nor Rwandan engineers, technicians or economists from OPYRWA', the public sector agency responsible for pyrethrum production in Rwanda, participated in the choice of processing technique or technology supplier. Because its bid appeared lower, an Austrian firm was chosen to build the refinery. Later it became evident that had the cost of plant construction and insurance been included, this firm would not have been the least cost supplier.

72. The Austrian firm, moreover, was inexperienced in the construction of pyrethrin refineries and its process was, as yet, untried. The Rwandan Government thus requested that additional guarantees and penalties amounting to 17 per cent of the project's $5.1 million total costs be written into the agreement. While the United Nations organization did raise the penalties to 10 per cent in its contract with OPYRWA', no clause compensating OPYRWA' was contained in the separate agreement that the former organization signed with the Austrian firm. When, in 1982, three years after start-up it had become evident that the Austrian process could not produce pyrethrin extract to meet international standards, OPYRWA' thus had no means of redress.

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[38] These include another of Rwanda's major exports, quinine, as well as jute from Bangladesh and sugar in several LDCs.

[39] This case study is based upon an unpublished paper by A. Mugesera "Office du Pyrethre du Rwanda (OPYRWA')" presented at the Atelier National de Recherche sur la Politique Technologique au Rwanda sponsored by the Republique Rwandaise, Ministère de l'Industrie des Mines et de l'Artisanat and the International Development Research Centre (IDRC) of Ottawa, in Kigali, from 18-31 May 1986.

73. This crisis led OPYRWA' to exercise greater direction over the acquisition process and to move more deliberately forward towards mastery of the operating technology. In 1982 UNIDO turned the management of USINEX over to the Rwandan Government and OPYRWA' launched a two-year process of rehabiliating and enlarging this plant. Although the machinery and equipment were purchased abroad, their choice and their installation were undertaken by Rwandan chemists, engineers and technicians. In 1984, OPYRWA' assumed the responsibility for choosing a firm to rehabilitate the refinery. The project, whose cost was $2.1 million was partially financed by UNDP.

74. One of the original British contenders, a firm specialized in pyrethrum refining, was chosen. Having learned the importance of bargaining, OPYRWA' now sought to better protect its interests. Its contract with the UK firm thus stipulated that the cost of all modifications undertaken during start-up were to be born by the technology supplier.[40]

75. From its active participation in the process of chosing and negotiating with is technology supplier, it is evident that despite its limited human and financial resources, OPYRWA' has mastered many of the capabilities needed in the technology acquisition phase. But it has not been able to go forward towards mastering technology in the "utilisation" phase. In part this is due to the fact that rehabilitation has consisted mainly in the substitution of one process for another. The new process is licensed from the UK supplier at a cost of 1 per cent of net profits on refined pyrethrum extract over a ten-year period. In so far as mastery of operating technology is concerned, therefore, the change in refining process has been something of a setback since its operation requires considerable retraining of OPYRWA' technicians. It will thus be some time before Rwandans are able to manage all aspects of production.

76. The new refinery became operational in 1986. Because of the long delay in constructing a workable refinery, Rwanda lost nearly 15 years of revenues on the sale of refined pyrethrum at a time when world prices for this commodity were high. Errors in the choice of technique for the first refinery also meant that during this period debts were incurred and accumulated. By 1984, with operating loses at 94 million Rwandan francs, OPYRWA' had long-term debts of 391 million Frw and short-term debts 253 million Frw . Indebtedness, the current fall in world prices and the contraction of world demand for natural pyrethrum, threaten the future of this project.

2. *Utilization: three cement cases*

77. Cement, on the other hand, is a product destined for domestic markets. A recent study of 33 clinker and cement plants in 16 African countries undertaken by the Paris-based Institut de l'Entreprise, however,found that six of these plants had closed down by 1982-1983, 21 were operating sub-optimally and only six were producing at 70 per cent or more of capacity.[41]

78. The three cases presented here, one from Rwanda, another from the United Republic of Tanzania and the third from Benin, suggest a number of factors that have contributed to this poor production record. From these cases, for example, the importance of local participation in the planning stage becomes immediately apparent. So, too, does the need to search for alternatives that permit Governments to reconcile conflicting goals. Both of these factors point to the need to strengthen those indigenous technological capabilities associated with the acquisition phase. The effect on capacity utilization and on production costs of operating energy-intensive plants that depend upon imported oil is a third commonality in this industry and it becomes an even more serious liability to the extent that other inputs, including managerial and technical skills, are also being imported. The need to bring technology into the planning process and the utilization phase emerges clearly from these cases.

79. As part of an industrial decentralization policy, Rwanda's Mashyuza cement plant, a State-owned enterprise built in the 1980s with a loan from the People's Republic of China (PRC), was located far from its markets.[42] The site, relatively close to a dam, could have been advantageous,

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[40] Under the terms of its contract with OPYRWA', the United Kingdom firm also agreed to market 50 per cent of the pyrethrin extract in exchange for a 5 per cent commission on these sales. Although the UK firm is not a shareholder, it is nonetheless assured of an income flow from this venture.

[41] Institut de l'Entreprise, **Pour un vrai partenariat industriel avec l'Afrique, Bilan et perspectives de l'industrie africaine.** (Paris: Institut de l'Entreprise, Centre Nord-Sud, mai 1985), pp. 53-54.

[42] This case is based on an unpublished paper by F. Nyagahima "Les cimenteries" presented at the Atelier National de Recherche sur la Politique Technologique au Rwanda sponsored by the Republique Rwandaise, Ministere de

however, had an energy-efficient, "dry" cement-making process using hydroelectric power been chosen. The choice of technique was left to technicians from the loan-giving country, who designed, constructed and managed the plant. The "wet" process they chose, relies heavily on oil imported through the port of Mombasa and trucked overland into Rwanda. With production at 64 per cent of capacity in 1985, imported fuel oil accounted for 52 per cent of production costs. Although the Chinese are well known for effectively transfering technology - the Friendship Textile Mill in the United Republic of Tanzania is a case in point - a lack of qualified staff at all levels meant that a year after start-up, 80 Chinese technicians were still being employed in the plant - one for every four Rwandans .

80. By appointing a supervisory board of 12, six each from the two participating countries, Nigeria and Benin, the evolution of the Onigbolo Cement plant (Benin), gave the appearance of more intensive local participation. But because civil servants are transferred frequently, "...between 1974 and 1981, no less than 33 officers had represented Nigeria on the "Board"...some attended only 1 meeting each before moving on".[43] The ability to accumulate knowledge was thus considerably diminished in the planning stage and as it turned out in the design and construction phase as well since local engineers were not hired until the plant was nearly completed. Despite its supervisory powers, few of the Board members had experience in this sector. As a result, insufficient testing of local inputs was not corrected during the planning phase and only when production began was the high water content of local limestone discovered. The cost of grinding the wet stones and drying the raw meal to meet product specifications has seriously affected production costs. Higher financing charges have also increased total costs. These resulted from a failure to secure project funding prior to undertaking negotiations with the various contractors who would be involved in the project. Instead, each contractor brought in its preferred financing institution,leading to multiple negotiations and harder financial terms. Costs also rose because the project was not completed on time and the contract contained provisions indexing costs to inflation in Denmark and Belgium. Lastly, additional costs were incurred because at the moment of takeover, only 30 per cent of the facilities had been fully tested.

81. CIMAO, a World Bank funded Côte d'Ivoire-Togo-Ghana joint venture located in Togo began operation in 1980.[44] Three years later, production costs were still almost twice those projected in the feasibility study. As a result, the price of clinker imported from CIMAO and sold in Côte d'Ivoire was 74 per cent over that of clinker imported from Europe. CIMAO can be considered to have been ill conceived from the outset. The feasibility study prepared by the project's promoter was based on exaggerated expectations of rising clinker prices, despite the fact that excess capacity in Europe has kept clinker prices low since firms in the industry export only a small percentage of their output and tend to use marginal pricing for exports. This drives international clinker prices down and makes it increasingly more difficult for plants in relatively higher cost regions like Francophone West Africa to compete. To offset this difficult competitive environment special attention must be paid to the choice of technique and to the training needed to bring costs down after start up. This was certainly not the case here. To the contrary, the plant was overdesigned by its engineers who chose expensive technical solutions. Investment costs thus rose as did the firm's debt. Although use of a coal-fired plant had been suggested at the outset, the plant was designed to use electricity produced from imported fuel oil. The low sulphur content of this fuel, the use of siliceous sand and the frequent power shortages due to a scarcity of foreign exchange, resulted in the need for frequent rebricking. This in turn led to low capacity utilization and higher unit costs. In April 1984 the CIMAO plant was shut down truncating an industrialization venture that had generated backward linkages to the extraction and processing of local raw materials, contributed to the building of indigenous technological capabilities in a small least developed country, and promoted intra-regional trade.

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l'Industrie, des Mines et de l'Artisanat and the International Development Research Centre (IDRC) of Ottawa, in Kigali, from 18-31 May 1986.

[43] This case is based on Akin O. Adubuifa, "The Onigbolo Cement Story or How to Snatch Defeat from the Jaws of Victory" unpublished paper, Ibidan: University of Ibada, 1982, p.4.

[44] This case is based on World Bank, Project Performance Audit Report CIMAO Regional Clinker Project (Washington, D.C.: IBRD, Operations Evaluation Department. Report NO. 7328, 23 June 1988) and République de Côte d'Ivoire, DGCTX, Plan National de Transport, Monographie sectorielle ciment (avril: 1988).

3. From utilization to absorption

82. Many of the problems encountered in the cement case could have been avoided through better information collection and assessment, a more careful technology selection process and the provision of incentives for technology mastery. As the two cases presented here, however,show this is a lengthy process and its success depends heavily upon local participation in the process of technology choice and change.

(a) Textiles in Bangladesh

83. In 1947, Bangladesh, or East Pakistan as it was called, had only 10 cotton textile mills with an installed capacity of 109,740 spindles and 2,717 looms. By 1969-1970 installed capacity had risen to 750,000 spindles and 7,000 looms and some 131,000 people were employed in the industry. Following its independence from Pakistan in December 1971, Bangladesh was obliged to accomodate a substantial increase in the labour force at the same time as it lost a large number of non - Bengali managers and technicians. The Government of Bangladesh now stepped in to run and ensure the development of this industry.[45]

84. Between 1970 and 1975 the labour force in the textile industry (ISIC 321) rose 43 per cent. Imports of textile machinery during this period, however, were modest as shown by the low and relatively flat "M" curve in figure 5. Under these conditions, productivity should have declined in this period and indeed it briefly did. But the index of machine productivity (1969-1970 = 100) which had dropped to 67 for spindles in 1972-1973 and 53 for looms in that year had risen by 1976-1977 to 80 for spindles and 82 for looms.[46] This suggests that the short-term vacuum in technical and managerial skills within the industry was being rapidly overcome. Even more interesting is the steady increase in labour productivity in the early and mid-1970s, as shown by the "Q" curve in figure 5. These productivity increases began well before the steep increase in capital goods imports took place in 1978. Not only had productivity increased but the sector as a whole had expanded. By 1978 Bangladesh's 48 textile mills had an installed capacity of 982,000 spindles and 8000 looms and employed 260,000 persons.

85. The Bangladesh textile industry thus provides an illustration of the way in which the development of indigenous technological capabilities through an incremental and deliberate process of "learning-by-doing" laid the basis for the rapid absorption of new textile machinery and the dramatic rise in textile exports, as represented by the "E" curve in figure 5, in the post-1978 period. Figure 5 graphically represents these interrelationships.

86. Building indigenous technological capabilities in the textile industry may also have contributed to the post-1978 boom in clothing exports. In 1978 the growing restrictiveness of the Multifibre arrangement induced Republic of Korea and other textile and clothing manufactures to seek out partners in low wage countries with underutilized quotas. The arrival of these investors in Bangladesh brought with them complementary skills in marketing, subcontracting and in some instances design then lacking in that country. Whereas Bangladesh had barely a dozen clothing firms in 1978, by 1985, there were some 450 establishments employing 140,000 persons.[47]

87. As in the pyrethrum case above, however, despite the mastery of many of the basic operating capabilities, the existence of low wages and a local supply of cotton, the future growth of this industry is not assured. Once again a key factor is the vulnerability of the least developed countries to external conditions. Restrictive trading practices in the developed market economy countries is a case in point. Although the protocol extending the multifibre arrangement to 1991 (MFA IV) specifically committed the signatories not to impose quotas on the least developed countries or on those developing countries that were tiny suppliers in DMEC markets, France, the United Kingdom and the United States have all restricted Bangladesh imports.[48]

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[45] Ahmed H. Quazi, op.cit. fn. 31 above, p. 23.

[46] Ibid.

[47] IBRD, Rapport sur le développement dans le monde 1987, p. 187.

[48] Ibid.

(b) Maize milling in the United Republic of Tanzania

88. Vulnerability of a different sort marks current plans to rehabilitate the National Milling Corporation (NMC) in Tanzania.[49] Here donor agencies, in particular, the World Bank through its affiliate, the International Development Association, and national aid agencies in the United Kingdom and the Federal Republic of Germany that normally act upon the World Bank's recommendation, are shown to be powerful forces shaping technology alternatives in the least developed countries.

89. Over the past several decades an extensive custom milling sector based on the use of hammer mills developed in Tanzania. A hammer mill consists of a horizontal rotary shaft carrying high speed rotating discs to which a number of hammer bars are fixed. The outer casing has a screen that regulates particle size. Because screens of different mesh size can be used the hammer mill has considerable flexability in milling a variety of grains. Hammer mills are powered by either electric motors or diesel engines. Initially all hammer mills in Tanzania were imported. By the 1980s, however, the entire mill body was manufactured locally in four sizes and local capacity also existed to assemble electric motors. Of the 41 custom hammer mills covered by a recent survey, some 58 per cent used locally-made mills. Thus "the development of local capacity in the manufacture of hammer mill equipment has widened the range of choice for this technology".[50]

90. In addition to private custom millers, Tanzania's National Milling Corporation (NMC), a parastatal company, operates six large-scale roller mills and a number of hammer mills. Although the nominal capacity of these six mills is estimated at 113,300 metric tons per year on a three shift basis "...chronic mechanical breakdowns and spare parts problems coupled with power supply problems have resulted in low levels of capacity utilization." As a result, NMC has been obliged to contract private customs millers to mill a portion of its grain. Of total NMC annual sales of partially degermed maize flour between 1980/81 and 1983/84, about 41 per cent was milled by private custom millers.[51]

91. As the above illustrates, not only is the large-scale imported roller mill technology less efficient under existing conditions, but the absence of significant economies of scale suggests that the alleged cost advantage of large-scale firms may not always hold. A careful analysis of input coefficients and cost-benefit ratios, moreover, provides considerable evidence of the economic viability of the custom milling sector in terms not only of employment generation but of the effective utilization of capital and surplus generation.[52]

92. From a technological perspective, the operational manageability of the custom mill is an added advantage. In small milling firms, for example, there is a lower demand for specialized operational and management skills because such mills require "little or no stock control, modest skill in plant operation and maintenance tasks and rudimentary book keeping abilities". This is desirable where skilled labour is scarce and it facilitates the formation of alternative skills through informal training such as apprenticeship and experience gained over time. Many of the entrepreneurs who started up custom mills had passed through a period of apprenticeship and experienced workers in some of the mills are able to carry out routine repairs that in the roller mills require skilled mechanics. While the custom milling sector plays a role in the process of skill formation, the more capital-intensive technology does not substitute for scarce managerial skills, as is widely believed, but rather creates an increased need for them.[53] Of total personnel employed in Tanzania's roller mills, 16 per cent, accounting for 50 per cent of the wage bill, are professional managers and supporting secretarial and accounting personnel.

93. Why despite the clear economic argument for developing larger custom hammer mills do plans for rehabilitating the National Milling Corporation accept expansion of the roller mills sector as the preferred option? Factors such as the importance associated with large-scale management or the esteem that comes from operating modern technology may also figure into the explanation. But an analysis of how investment decisions are made within the NMC showed "that in all cases involving decisons to rehabilitate and/or establish new additional milling capacity, it was mainly

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[49] This case is based on an unpublished study by M.S.D. Bagachwa entitled "Technology Choice in Industry: A Study of Grain-Milling Techniques in Tanzania" completed in 1989 and funded by the IDRC, Ottawa.

[50] **Ibid, page 84.**

[51] For reasons of energy efficiency roller mills in Tanzania have for some time been prohibited from producing the finest sifted white flour. Both techniques thus produce and sell substantially the same product. **Ibid.**, p. 90.

[52] **Ibid.** p. 122.

[53] Of total personnel employed in Tanzania's roller mills, 16 per cent, accounting for 50 per cent of the wage bill, are professional managers and supporting secretarial and accounting personnel. **Ibid.** pp. 114-117.

the foreign financing agency which identified, selected and negotiated with the project engineering agency". In part this was due to the fact that for historical and institutional reasons the NMC lacks the operational command or technical know-how to undertake the feasibility studies, identify civil engineers, machinery and input suppliers. But this and other studies of investment projects in the United Republic of Tanzania show that there is a close tie between the availability of financing either in the form of suppliers credits or tied aid and the source of equipment.[54] Foreign aid is thus a major factor shaping the choice of technique and the consequences that flow from it in the least developed countries.

B. Agriculture

1. The acquisition phase: improved livestock and fruit trees in Nepal

94. Foreign aid agencies, however, have no monopoly on the imposition of external 'solutions'. For a variety of reasons, including the belief that speed precludes participation, government ministries often reinforce the tendency to adopt a top-down approach that ignores the wishes and needs of technology users, as the Karnali-Bheri Integration Rural Development Project (K-Bird), which began in 1981, demonstrates.

95. The K-Bird project has as its overall objective "to increase the capacity for self-initiated and sustainable economic, social and environmental development in the mid-west region of Nepal".[55] In its rhetoric it thus appears to subscribe to the view that local rural community institutions involving the whole community in the programme project cycle are crucial to self-sustainable development. Yet in practice, the operating ethos of this project in its first two phases, 1981-1985 and 1985-1990, has hardly conformed to the kind of participatory model this implies. One indication of the gap between aspiration and results, is the very high percentage of the budget, over 50 per cent, expended on administration and management. This alone would not be decisive were it not for the fact that so little of this money has been spent on animation and both project design and target setting are marked by little input from the villagers directly concerned. As a recent evaluation of the K-Bird project pointed out, villages are not formally organized to ensure full participation and even if they were, their participation is discouraged by the fact that targets are presently set by national government ministries.

96. A number of negative factors flow for technological learning and for technology-based linkages from the centralization of target setting in the K-Bird project. First, sub-projects are not co-ordinated amongst themselves, thus losing opportunities to reinforce advantages or attenuate problems. Second, centralization creates vertical lines from the village to national or regional centres of administration by-passing the creation of local linkages needed for problem-solving tasks. Third, centralization deprives villagers of the kinds of input - choice of target, participation in design and construction - that builds a positive appreciation of the project and both the desire and the routines necessary to successfully maintain it. Fourth, the nature of the targets themselves are a problem. Targets set by the centre are designed to measure inputs - number of improved livestock, new seeds or saplings distributed - rather than consequences - for output over the long term, for the distribution and level of income, for the sexual division of labour, for productivity or other. These factors can be illustrated with reference to the distribution of improved seeds, saplings and livestock.

97. Farmers, especially those who rely heavily on their production for subsistance, are keen to see tangible results from the use of new varieties. Diffusion of new varieties is thus slow if these are not immediately evident. Farmers in the K-Bird area, for example, readily adopted improved vegetable varieties, particularly radishes, because increased productivity of these varieties was evident. In the case of new rice varieties, however, both acceptance and productivity gains seem to be lower. Diffusion could probably be accelerated if additional research were undertaken to ensure that the varieties being supplied are superior under local conditions. This would, however,

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[54] See, for example, R. Skarstein and S.M. Wangwe, Industrial Development in Tanzania: Some Critical Issues (Dar-es-Salam: Tanzania Publishing House in co-operation with the Scandinavian Institute of African Studies, Uppsala, 1986).

[55] This case study is based on Agro Strategies International Inc., K-Bird Mid-Term Evaluation, Final Report, prepared for the Canadian International Development Agency (November 1988).

require more field trials to test locally for highest yield. Co-ordination amongst sub-projects may also make a difference here, especially with regard to increasing yields. Irrigation schemes could be co-ordinated with credits for improved seeds, for example, to ensure that the greatest benefits, in terms of yields, are obtained from irrigation. Irrigation projects, however, are a classic case of failure due to a lack of local participation in the identification, decision-making and planning stages. Incomplete projects or projects that are not maintained for lack of interest on the part of the community or lack of savings by the community for repairs are the rule rather than the exception and only one irrigation scheme of the six was co-ordinated with enhanced agriculture extension activities.[56]

98. The distribution of fruit tree saplings has been even less successful than the rice improvement project. This occurred primarily because targets set at the centre did not correspond to the wishes of local farmers. Thus interviews in the region revealed that "agricultural officers find themselves obliged to beg farmers to take pear trees in Dailekh in order to meet their targets, while farmers want to grow mango trees. Government targets are based on considerations of technical production potential whereas Dailekh and Jumla farmers base their decisions on marketing issues such as lack of transportation".[57]

99. Both acceptance of a new technology and the successful use of it are seriously compromised by the top-down approach to target setting used here. The negative impact on resource utilization, moreover emerges clearly from the experience with improved livestock in the K-Bird area. As with seeds and saplings, the centre sets targets for national production levels and requires that a given number of improved breeding stock be distributed. Each district is given a distribution target but neither the type of animal nor the number distributed necessarily reflect local demand or local conditions. One example is the promotion of Jersey cattle for their higher milk yields where custom does not allow farmers to sell milk and the bulls cannot be used for plowing because they lack the hump required for carrying a yoke.

100. The mismatch is also evident in the case of other improved livestock. Jumla herders who migrate seasonally out of the K-Bird region use their sheep and goats mainly for transport. Breeding stock supplied by the centre, however, is aimed at improving meat and wool production. The result is that "farmers who accept them find they increase their work load because of increased fodder requirements without producing adequate benefits in return; their health status is difficult to maintain and most of them deteriorate and die".[58]

101. Since little monitoring of the impact occurs, subsequent plans and projects cannot be improved on the basis of past experience. Lack of local participation, moreover, means that these projects remain dependent upon government institutions. When this institutional support is withdrawn, there are no structures in place to sustain the change.

2. Technology absorption: tea cloning in Malawi

102. Diffusion of new techniques to smallholders has been far more effective in the Malawian tea industry in large part because of the close link between domestic research, local extension services and smallholder producers. This case also illustrates how careful selection in the choice of biotechnology techniques[59] can lead to positive employment, balance-of-payments, learning and

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[56] "Six different irrigation schemes were visited and discussions were held with farmers affected by the schemes. Of the six projects, two are completed and working well, one is partially inoperative because of a land slide and three are incomplete." Of those functioning well, one was completed by the user group and the other partially completed by contract. All incomplete projects were being constructed under contract with no user group involvement. No savings programme for maintenance was started under any of the incomplete schemes. **Ibid.** pp. 10-13 and Annex 4.

[57] **Ibid.** p. 8.

[58] **Ibid.**, p. 14 and Annex 5 Ramesh Sharma "Agriculture and Livestock" Working Paper prepared for the K-Bird Mid-Term Evaluation (February 1988).

[59] "Biotechnology permeates many scientific specialities and is not exclusively the domain of biological sciences. To genetically engineer an organism, be it a microbe, plant or animal, requires knowledge and techniques from many scientific disciplines: biology, chemistry, biochemistry, physics, computer sciences, electronics, agriculture and animal hubandry, to name but a few. The expertise of scientists and technicians, together with traditional agricultural labour components, is required to take the investigations of biotechnology out of the laboratory and into the commercial markets. The continuing involvement of scientists is essential not only during the R and D period, but also in the bio-production process and other phases which bring the outgrowths of the initial biotechnological research into the market-place." Harold H. Lee and Frederick E. Tank, "The Socio-economic Impact of Agricultural Biotechnology

linkage effects.[60]

103. Tea is the major commercial crop in Malawi.[61] It contributes over 20 per cent to the country's exports and employs nearly 10 per cent of the employed labour force. Most tea is produced by 21 firms on a total of 61 estates. Since 1967 the Small holder Tea Authority (STA), a government agency, however, has been providing smallholder farmers with technical assistance and improved inputs developed through a programme of deliberate breeding followed by clonal selection carried out by the Tea Research Foundation of Central Africa. By 1986 there were 4,815 small growers producing nearly one third of the tea grown in Malawi.

104. During the 1960s much of the work undertaken by the Tea Research Foundation (TRF) was directed towards the established commercial tea estates which could afford the management and agronomic inputs required for successful tea growing. In conjunction with the biochemistry section, the plant improvement section therefore devoted nearly all of its breeding efforts towards establishing reliable selection criteria for quality. As smallholder tea growing became more important, the TRF attempted to cater more for their needs - selecting for resistance to insect pests and drought resistance as well.

105. Adoption of improved varieties of tea on the older tea estates has been slow in large part because replanting is constrained by the financial losses incurred while waiting for the plants to mature. Two newer estates established since the breeding process began, however, grow polyclonal and clonal tea respectively and most of the tea grown by smallholders is a product of biotechnological intervention. The close linkage between the R and D sector and the government authority promoting smallholder tea growing has largely been responsible for the diffusion of clonal and polyclonal tea to this sector.

106. Although yields have not been as high as expected from the adoption of these improved tea varieties, in part because many of the plants have not yet reached maturity and in part because of poor pruning and plucking techniques, a number of positive consequences have resulted from the application of biotechnology to tea growing. In contrast to the expected decline in employment, for example, labour intensity per unit of land actually rose by some 23 per cent. This net gain in employment was brought about by increased labour use in the nursery and planting operations involving the development of the clones and their establishment in the field. Labour use in weeding and plant protection, on the other hand, is lower for biotechnology plantations due to the reduced use of herbicides and pesticides. But this feature of the new varieties brings with it the additional advantage of substantial savings in foreign exchange since pesticides, fertilizers and herbicides are all imported.

107. The application of biotechnology to tea growing has also increased demand for research skills. These highly skilled posts, however, appear to be filled mainly by expatriate personnel on contract to the Tea Research Foundation. Training of research staff and the establishment of links to biotechnology and tea research institutes outside of Malawi would accelerate the process of technological mastery in this sector.

108. The direct economic benefits resulting from the shift in research objectives at the Tea Research Foundation demonstrates the utility of focusing more on user needs. Developing a more risk-free tea variety, for example, has undoubtedly helped speed its diffusion among smallholders. It has also enhanced smallholder revenues since world prices for polyclonal tea are higher than for other varieties. The issue, then, is not whether biotechnology is appropriate to conditions in the least developed countries but which components of the new technology should be mastered locally and which accessed, for example, through networks with laboratories in other developing or developed countries.

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on Less Developed Countries" (Geneva: ILO, World Employment Programme Working Paper, No. WEP 2-22 WP.199, January 1989, p. 3.

[60] Improved enzyme techniques, for example, have allowed high fructose corn syrup to be produced economically thus competing directly with saccharose from sugar. RDNA techniques will eventually permit the expression of the gene for thaumatin, a natural product 250 times sweeter than sugar, to be expressed in other fruits altering the climatic requirements currently governing location. Tissue culture techniques are enabling large multinational corporations such as Unilever and Tate and Lyle to clone tropical plants in Europe and do the research needed to adapt them to new locations. Iftikhar Ahmed "The bio-revolution in agriculture: Key to poverty alleviation in the Third World?" in International Labour Review, Vol. 127, No. 1 (1988), pp. 53-72.

[61] *This case study is based on C. Chipeta and M.W. Mhango Technology and Labour Absorption in Malawi Agriculture*" (Geneva World Employment Programme Working Paper Number WEP 2-22 WP 191, December 1988).

3. Innovating in post-harvest operations: rice milling in Bangladesh

109. In addition to the linkage between R and D and production, careful assessment of the application of new technologies and the development of complementary capabilities to take advantage of the new opportunities they generate are essential to ensuring a broad range of positive development consequences from technology change. This is apparent from the rice hulling case below.

110. Three technologies are currently being used to mill rice in Bangladesh: automated rice mills, mechanized steel hullers and the hand operated dheki[62] By far the most costly and the most capital and foreign exchange intensive is the automatic rice mill. For the moment, this technology is not extensively used in Bangladesh. Steel hullers, however, have spread widely in rural areas and their use has resulted in a significant displacement of female labour particularly among landless women. Because steel hullers, however,are not as efficient as automated rice mills in terms of the rice recovery rate and the percentage of broken grains nor do they produce as high a quality of product, there are pressures to move towards more automated milling. The point of this case study is to suggest that other alternatives can be envisaged.

111. Over 10 per cent of total rice production in Bangladesh is husked by hired landless women using the dheki. This is equivalent to aproximately 20 million person/days of employment for the poorest 5 per cent of rural women. Currently with an estimated 10,000 steel hullers installed in rural areas, milling some 30 per cent of the crop, between 5 and 7 million person/days of productive employment are being lost each year. For the landless women involved, dheki work accounts for some 55 per cent of their annual income and may contribute as much as 15 per cent to total family revenues.

112. In several Bangladesh districts, poor working women have begun to use the higher productivity of these mills to their advantage by setting up paddy-husking businesses. Since these women rarely had the capital to purchase a dheki or the land on which to locate it, setting up their own dheki business was not possible and under existing conditions would probably not be profitable[63] But, by purchasing paddy, parboiling and drying it and then having it hulled at the local rice mill, women who live close to rural mills have been able to quadruple their output and earn higher profits.

113. The success of this organizational innovation, however, is crucially dependent upon the access these women have to credit with which to buy paddy. A number of agencies such as the Grameen Bank, discussed below, have begun to provide credit to the landless. Research into the possibility of extending such financing facilities to landless women for the purpose of starting a paddy-husking business or building a rice mill clearly must be undertaken. Equally important, however, is the need to upgrade the steel hullers and thus ensure the viability of this technology. As yet, for example,"no one has taken a serious look at the possibility of reducing the apparent food losses involved in using a steel huller or at ways of decreasing breakages and separating out good quality bran. Yet such research could be carried out at a fraction of the cost of the resources invested in automatic rice mills".[64] Because the hullers, belts, soaking, parboiling and winnowing equipment used by the rural steel hullers are made by local firms' and artisans, some of whom are landless women, development of steel huller technology would not only save scarce capital and foreign exchange and generate employment but it would contribute to the building of indigenous technological capabilities more broadly throughout the society.

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[62] This case is based on Gloria C. Scott and Marilyn Carr, **The Impact of Technology Choice on rural Women in Bangladesh** Problems and Opportunities (Washington D.C.: World Bank Staff Working Paper No. 731, 1985), pp. 61-76

[63] A recent study by the Bangladesh Institute of Development Studies, moreover, found that if labour costs are taken into account, husking businesses based on the dheki are not profitable. There seems little reason, therefore, to encourage this alternative. **Ibid**, p. 66.

[64] **Ibid**, p.70. Automatic rice mills have a greater effect on employment because they displace labour not only in milling but in pre-milling activities. In addition, automatic mills consume scarce capital and foreign exchange resources. The same input of paddy could be handled by rural steel hullers at 6-7 per cent of the investment cost for an automatic rice mill. As in Tanzania, automatic mills in Bangladesh are characterized by frequent breakdowns, difficulties in obtaining spare parts and hence consider*able underutilized capacity*. (pp. 68-69).

C. Supporting agriculture and manufacturing

114. Productivity improvement and continuous adjustment to change in agriculture and in manufacturing cannot be ensured without the development of the energy sector and the many auxilliary services, notably engineering, finance, education and training, that support change. This section deals with a number of innovative approaches to developing indigenous technological capabilities in energy and services.

115. The energy sector absorbs a sizable chunk of total investment outlays in most developing countries and rightly so since it is both a key input in the competitiveness of down-stream industries and an important element in the upgrading of living standards in these countries. In addition, the energy sector itself provides numerous opportunities for technological learning and for the establishment of linkages to research, engineering and other productive activities. As the two cases discussed here show, these positive technology learning and linkage effects were achieved in the United Republic of Tanzania and Nepal, despite the financial difficulties faced by the power sector in these countries.

116. Power utilities in most least developed countries face serious financial problems because the sector is still in its early stages of development. Its operational base is thus weak and yet it must bear a heavy burden of investment to build up the system. The Tanzania Electricity Supply Company Limited (TANESCO), for example, has increased electricity generation and sales overtime, but this has not been accompanied by a corresponding improvement in the company's net income position because operating expenses - fuel bills, arrears, electricity leakage and interest charges on bank overdrafts to cover current operations - have risen dramatically. There is, thus, a chronic liquidity problem. Despite a consistently positive return on net fixed assets in the period 1981-1984, TANESCO's operating ratio has deteriorated with the share of total sales revenue going to operating expenses rising from 59 to 84 per cent over the same period. The self-financing ratio has also deteriorated. A somewhat similar picture emerges from the data for selected Asian developing countries (table 10).

117. Both Tanzania and Nepal have placed considerable emphasis on building up the energy sector taking advantage of relatively cheap hydropower. In the case of Tanzania, efforts have also been made to extend the hydro-based grid system to displace electricity supply by diesel engine generation units in isolated stations and to overcome the fuelwood problem in certain localities.

118. During the period 1966-1986, TANESCO, a government-owned public utility, consciously undertook a process of building indigenous technological capabilities.[65] In its early years of operation, it relied quite heavily on expatriates. In the mid-1960s, for example only five of the 55 principal technical positions were filled by Tanzanians with graduate engineering degrees. By the mid-1980s over 100 Tanzanian engineers were employed by TANESCO and all top positions were staffed by local engineers with more than 15 years of experience. Only six expatriates currently serve as advisers in the areas of planning, project management and finance.

119. The successful effort to build up its own operating capabilities, was a result of deliberate government policy. In particular, TANESCO, established its own technical training institute and has graduated more than 200 technicians who are now working in the company's various installations. The company also utilized technical co-operation agreements with different foreign donor agencies to provide training for its personnel. Its ability to maintain, operate and extend the system demonstrate the extent to which TANESCO has successfully absorbed this technology.

120. Going beyond utilizaton and absorption, in Nepal, an emphasis on rural micro-hydro projects has led to the development of domestic engineering capabilities and to a process of technological innovation in the sector.[66] The technology for small water turbines was first introduced into Nepal in the mid-1960s when a Swiss-aided mechanical workshop in Kathmandu, Balaju Yantra Shala (BYS) began to manufacture and install turbines specifically adapted to the manufacturing capabilities and conditions in that country. The design for the cross-flow turbines they produced was gradually perfected and standardized with the aid of the Swiss organization in the early 1970s. Following this, a number of other producers entered the market. Currently there are ten producers of turbines with the top three firms, BYS, Butwal Engineering Works (BEW)

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[65] This case study is based on UNCTAD, "The performance of the power sector in developing countries," (Geneva: UNCTAD TT 78, 11 November 1987).

[66] This case study is based on Royal Nepalese Government, Water and Energy Commission Secretariat (WECS) Report of the Task Force on Rural Electrification Impacts in Nepal, Vol. I, Main Report, Report No.: 4 4 220688 1 1 SEQ. 308 (February 1988) and UNCTAD, "Small-scale hydropower projects in Nepal" (Geneva: UNCTAD TT 62, 1987).

Table 10

Operating ratios and self-financing ratios for selected electric power utilities in the developing countries, 1982

(in percentages)

Country	Operating ratio [a]	Self-financing ratio [b]
Bangladesh [c]	119	-9
Nepal [c]	100	4
Indonesia	88	21
Malaysia	87	20
Myanmar	83	NA
Thailand	80	35
Tanzania [c]	79	6
Sri Lanka	69	43
Rep. of Korea	69	39

Source: UNCTAD, "The Performance of the power sector in developing countries", Geneva: UNCTAD TT 87, 12 November 1987, tables 2 and 3.

Note:

a Ratio of operating expenses and interest chargeable to operating and other revenue.

b Ratio of internally generated cash-less debt service to capital investment plus interest during construction.

c least developed countries

funded by the United Mission to Nepal and the National Structure and Engineering Company accounting for 77 per cent of the output.

121. Further research in the late 1970s and early 1980s, by the Research Centre for Applied Science and Technology (RECAST) of the Tribhuvan University led to the development of an improved water mill that has a power output sufficient to run a rice huller as well as a small electric generator. A modular version of the mill called a Multi-Purpose Power Unit (MPPU) is now being manufactured by the National Structures and Engineering Company.

122. Deliberate government policy has been an important factor in the development, production and diffusion of micro-hydro technology. RECAST, a government-funded research organization, played an key role in developing the MPPU and continues to provide technical services and to promote the use of small mechanical turbinesand other renewable energy technologies. Demand for the new turbines and MPPUs was stimulated by credits provided by the Agricultural Development Bank of Nepal (ADBN). ADBN has not only been a major financer of turbine and MPPU installations but it has also served as a catalyst for the development, promotion and dissemination of micro-hydro installations through its nationwide field network. This network of 362 field offices includes 160 Small Farmers Development Projects and 2 Appropriate Technology Units.[67] Lastly, "because the domestic market is small and local manpower trained in industrial skills so scarce...the indigenous manufacturing industry... composed of small enterprises has difficulty competing with imported goods from India. However, the manufacturers of mechanical drive units are today given contract allocations under the Agricultural Development Board lending programme which protects them to a certain extent from import competition." [68] Supply and demand for technological innovation has thus been fostered through a coherent programme of action.

123. More often than not, however, the linkage between supply and demand in the generation of new or adapted technologies is not well developed in the least developed countries. The case

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[67] G.R. Shrestha, "State of the Art of Micro and MPU Hydro Power in Nepal" paper prepared for a Planning Workshop on Micro and MPPU Hydro in Nepal organized by the Water and Energy Commission, Kathmandu, 19 September 1985, p.4.

[68] UNCTAD, "Small-scale hydropower projects in Nepal" (Geneva: UNCTAD TT 62, 1987) p. 15.

of engineering design and protype development services and their relationship to their potential client base in Sierra Leone is a case in point. A recent UNCTAD survey of the metalworking sector in that country reported that "little effort has been made in respect of design in the existing metalworks sector in Sierra Leone. Most of the private enterprises visited are producing items using imported machinery and equipment to manufacture standard parts. None of these enterprises has a design and engineering department/office or unit set up as an integral part of the business."[69]

124. Nevertheless, some design and prototype development capacity does exist and is called into application when specific requests are made. One company, for example, designed a refuse cart to be placed in urban areas for a project financed by an international organization. In other instances, development of agricultural machinery and food processing equipment such as seeding machines, paddy weeders and cassava grinders is blocked by the absence of users. This, as the report points out, occurs despite the relatively low price for such equipment because most farmers in Sierra Leone lack access to credit for such purchases. As we saw in the micro-hydro case, a co-ordinated policy affecting both demand and supply is clearly required to stimulate innovation and its diffusion.

125. A number of innovative approaches to technological change and to the building of indigenous technological capabilities, however, can be found in the service sector, particularly in the transfer of skills, in organization technologies and in the development of facilities to finance local development initiatives. One of the oldest of the successful and adapted training programmes, for example, is the Maritime Institute in Tuvalu. Over the course of its history it has trained seamen for service in the merchant marine of many European countries. Today, this innovative venture is threatened by technological change in maritime transportation, notably the containerization of freight and the use of computers. Because least developed countries are finance-poor, their ability to adjust to such changes is limited. Self-organization, self-direction and self-financing are shown to be keys to successful technological development and change in the last two cases we are covering here.

126. In Rwanda, an ILO programme whose objective was to overcome the isolation of small-scale urban producers by encouraging them to organize and to use their organizational strength to obtain better access to production resources, acquire occupational skills and so improve their earning capacity, has proved remarkably successful. The programme began in 1982 and over the next six years KORA, the craft confederation that was formed, secured the backing of the country's president . By 1988, KORA had 71 grass roots associations and eight intermediate trade federations. The model adopted in Kigali, the capital, moreover, had been copied by craftsmen in three other towns, Butare, Ruhengeri and Gisenyi.

127. In negotiations with the Mayor of Kigali, KORA was granted the right to stand surety for each of its member associations and to countersign work cards. The mayor also provided incentives to the craft associations by reducing personal taxes and allowing the option of a flat rate levy to be collected by the association itself. "As a result, payments into the local government funds have been higher and more regular; for their part, the craftsmen are left to work in peace".[70]

128. KORA has been particularly important in promoting savings and credit facilities through which craftsmen have been able to gain access to capital goods and in doing so by creating a joint account with the Rwandan People's Banks. This approach to technology acquisition has a number of advantages particularly for sustainability over the long term. "Groups that raise their own funds", for example, "are less vulnerable and less dependent on outside assistance. The use of personal savings as joint surety helps to foster a sense of responsibility among the participants for the management of their investments. By applying to the local banks and negotiating better credit facilities with them, it has been possible to establish durable relations between previously ignored economic agents and the established financial system."[71]

129. Some 2,800 crafts people covering 15 different trades are members of KORA. Between 1982 and 1987, 679 members of KORA received training in enterprise management, literacy and technical know-how in the fields of ironwork, welding, electro-mechanics and shoemaking. A mid-term survey of KORA member-associations at the end of 1985 showed that the impact on

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[69] UNCTAD. Technology and development perspectives of the metalworks and engineering products sector in Sierra Leone (Geneva: UNCTAD TT 75, 1986), p. 17.

[70] This case is drawn from C. Maldonado. "The underdogs of the urban economy join forces: Results of an ILO programme in Mali, Rwanda and Togo". International Labour Review, Vol. 128, No. 1 (1989), pp. 65-84, p. 70.

[71] Ibid, p. 72.

incomes of the credit and training programmes that had been implemented to that date had been impressive. Of the 20 associations for which data were available, incomes had risen in 18, remained stable in two and fallen in only one. To test whether the rise in incomes was due to extended hours of operation or to productivity increases, the survey sought data on hourly income. In 16 of the associations hourly income increased significantly, with average hourly income rising by 33.5 per cent. The importance of credit facilities in generating productivity gains and hence increased income was even more remarkable. Average hourly income of workers in the 12 associations which had obtained credit rose by 36 per cent and in the eight which had not yet obtained credit by 26.4 per cent.[72]

130. Similar positive results from self-organization and self-financing have been recorded in the case of the Grameen Bank Project (GBP) in Bangladesh. The Grameen bank targets the landless and offers short-term small-scale, low-cost credit without collateral to small groups for income generating projects. "By the end of 1982, 24,000 group members, of whom over 9,000 were female, had taken loans through 25 Bank Units reaching 428 villages".[73] The default rate on these loans is less than one per cent and the range of activities they have supported includes trading, livestock and fisheries, processing and manufacturing, services, shopkeeping, agriculture and forestry[3] Among the factors accounting for the Grameen Bank's success is its development of "...a framework whereby people themselves provided the market intelligence and are self-selective as appropriate customers for the GBP services. Peer pressure reduces the administrative costs and the rotational loan application procedures between group members ensures a continuing interest in the group as a necessary economic organization'. The savings element helps to build financial security." [75]

D. Towards a conclusion

131. While these case studies cannot provide detailed coverage of all of the issues involved in the acquisition, utilization, absorption and generation of technology, they do touch upon many of the fundamental problems and dilemmas faced by donors, host Governments, and a variety of economic and social actors with respect to the relationship of technology to development. There are thus many lessons we can learn from them. The broadest of these concerns the design of development policies and aid programmes themselves. As these case studies reveal, considerably more emphasis has traditionally been placed by policymakers in donor and least developed countries on the transfer of technology than on its domestic development and within this framework on the transfer of machinery and equipment rather than know-how. More often than not, the lack of participation by users in the process of choice and inattention to the process of technological mastery led to problems in production and difficulties for sustainability. In contrast, as the successful cases of technological innovation discussed in the last section illustrated, advances in productivity and major gains in income are being obtained through changes in organizational technology, greater participation by technology users in the process of technology choice, efforts to improve indigenous techniques and innovate on the basis of imported technology and through programmes that combine the provision of production skills and of credit. Some policy issues related to the implications of these findings for donor agencies, host Governments and other social and economic actors will be discussed in the concluding chapter.

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[72] Ibid, p.77.

[73] Information on the Grameen Bank is drawn from Janice Jiggins, "Rural Women, Money and Financial Services" Community Development Journal, Vol. 20, No. 3 (1985), p. 168.

[74] The Grameen bank has also experimented with giving credit to a group of 30 landless women to facilitate their joint ownership of a small rice mill. This is obviously a more difficult scheme than establishing a paddy husking business and entails considerable training and organizational skill. Reports, thus far are encouraging and the Grameen Bank has given loans to three other women's groups for the same purpose. Gloria C. Scott and Marilyn Carr The Impact of Technology Choice on Rural Women in Bangladesh, Problems and Opportunities (Washington D.C.: World Bank Staff Working Papers No. 731. (1985), p. 67.

[75] Jiggins, op cit, p. 168.

Chapter III

CONCLUSIONS AND POLICY RECOMMENDATIONS

132. As the pace of technological change accelerates and international competition intensifies, uncertainty increases for policy-makers and producers alike. The changes, in turn, are fundamentally altering development requirements, adding the need for continuous adjustment to the traditional elements of sustained growth and structural change. To cope with this new reality, pressures are mounting to orient development processes everywhere towards the creation of more flexible production systems built upon a strong technological base.

133. The centrality of knowledge in the production process that this implies has serious ramifications for the LDCs since it considerably extends the range of indigenous technological capabilities whose mastery is essential for development. Moreover, it underlines the importance of combining R and D, planning and evaluation capabilities, design, engineering, management, marketing, maintenance and production skills with domestic productive facilities in such a way as to ensure a process of continuous adjustment. The structural weaknesses of the LDCs and the pattern of their involvement in the process of technology acquisition, utilization, absorption and innovation reveal, however, the limited extent to which these countries are able to respond to the new situation.

134. Over the 1980s, the base for flexibility in the LDCs has been further eroded. This has occurred in large part because of the unfortunate coincidence of constraints on domestic policies with a deteriorating external environment. Thus, as attention shifted away from longer-term, more dynamic development needs to short-term equilibria, structural adjustment programmes combined with sharp fluctuations in export earnings reduced the capacity to absorb imported technology and to generate or upgrade local techniques since these are strongly affected by the size and structure of the market for technology.

135. In the face of shrinking domestic demand and despite the expressions of increased support contained in the SNPA, aid flows have not kept up with the debt servicing requirements of the LDCs nor have they compensated for the decline in investible resources derived from exports. This is particularly damaging from a technology standpoint because foreign aid has been the most important channel of technology transfer for most of the LDCs. The lack of clearly specified targets and monitoring devices in the SNPA has undoubtedly contributed to the limited increase in technology flows through concessionary channels. But it is also the case that donor countries have not been utilizing the SNPA framework to shape their aid programmes, and the high level of tied aid has tended to impede the building of indigenous technological capabilities through learning by participating in the planning, design and implementation stages of aid programmes and projects.

136. After a dismal decade of slow growth and limited structural change, the LDCs cannot afford ten more years of stagnation, nor in today's dynamic and changing world can they placidly await an upturn in world prices for their principal exports. The ability of these countries to act successfully on their own behalf, however, depends to no small degree on the willingness of donors and international financial institutions to facilitate new initiatives. Several of these are discussed below under three headings: (1) rethinking the resource question; (2) building a commitment to technological change, and (3) shaping the domestic environment for technology absorption and innovation: the role of policies and the strengthening of the human resource base.

A. Rethinking the resource question

137. Increasing the flow of investible resources is a clear first step towards improving the technological base upon which a flexible economic structure can be built. At least three avenues need to be explored in an integrated manner in this connection: a reduction in the debt burden of the LDCs to stimulate technology-related imports; a rapid and substantial growth in rural incomes to stimulate domestic demand for technology; and an increase in external resource flows, principally in the form of concessionary aid by redesigning the aid process and aid projects for maximum efficient use of available funds. The three would require action by the Governments of LDC countries, donor countries and international financial institutions, particularly in view of the present structural adjustment programmes.

138. Most plans for debt relief focus on easier repayment terms. But extending the repayment period from 10 to 20 years and the grace period from 5 to 10 years will not alter the current debt situation of the LDCs. It may, in fact, lead to considerable difficulties in the future, as the debt accumulates with compound interest, unless there is a dramatic improvement in the creditworthiness of these countries. However, the list of original LDCs has increased and prospects in the immediate future look bleak indeed. Full debt repayment thus seems illusory, yet its burden weighs heavily on current efforts to implement new development approaches in these countries. Given that the LDCs' total debt is small relative to the world's major debtor countries and that much of it is held by Governments and inter-governmental lending agencies, writing down the debt appears to be a preferable alternative to further debt postponements as the most rapid means of increasing import capacity and hence access to the new capital goods and spare parts needed to rehabilitate industry and stimulate productivity increases in agriculture.

139. Increasing the supply of technology, however, must be complemented by efforts to stimulate demand for it. Rapid and substantial growth in rural incomes would help, and could be obtained by adjusting domestic prices and by securing better international sales terms for raw materials and agricultural commodities. UNCTAD has an important role to play in this regard. But a carefully planned framework for a policy to reduce vulnerability through diversification, and to improve productivity by upgrading local technologies and stimulating the absorption of imported techniques, strongly backed by Governments, will also be required.

140. Diversification can take place along two principal axes - horizontally into new commodities and new activities, the service sector for example, and vertically by moving forward into materials and food processing, marketing and distribution or backward into components and spare parts manufacture. Each of these new directions will require the enhancement of existing technological capabilities in the LDCs. There is scope, for example, for improvement in project selection both in terms of new projects to be undertaken and those to be rehabilitated. Feasibility studies that are today undertaken by parties with a vested interest in a particular outcome need to be replaced by others undertaken by more neutral agencies - indigenous consulting firms, government research and planning bodies, international advisory services. There is also a need to improve contract negotiations and to ensure that the equipment provided meets expectations. Procurement and monitoring skills are crucial here. Diversification in the LDCs will thus require new inputs of technical assistance to strengthen domestic technology selection and acquisition capabilities and to build the institutional management, engineering, marketing and research skills needed to sustain such an efforts and render it particularly flexible and dynamic. UNCTAD is not only well placed to provide such technical assistance, but as an independent source of information it can also play an important role in assisting LDCs to choose among processing activities and to sequence their development. Moreover, exploring how to make systematic use of the potential of NGOs in the preparatory work leading to the initiation of technological development projects may prove a useful means of developing international co-operation.

141. In contrast to a macro-economic approach aimed simply at restoring market forces, generating or upgrading local technologies will require the integration of a number of new policy initiatives. In rural areas, these will include the provision and co-ordination of access to training, credit and extension services and a deliberate effort to involve farmers in the process of technological planning. With regard to small urban producers, there is much to be learned from innovative projects such as the ILO's support for artisans in Rwanda. Several factors have contributed to the success of this project in strengthening the micro-enterprise sector and increasing its ability to absorb technology. First, small-scale urban producers were encouraged to organize themselves and to participate in the process of chosing the kinds of training and credit facilities they needed to improve productivity. Second, government support was crucial in legitimizing their efforts.

142. In addition to reducing the debt burden and stimulating domestic demand for technology,

increases in overall resource flows to the LDCs will be a vital component of their future viability. One way to increase such flows is to maximize the efficient use of existing aid resources. Some of the cases examined in the assessment report, however, reveal that most project planners take too little account of local resource inputs and rarely design projects around local contributions. The very design of aid projects thus increases complexity, creates a greater need for skills absent in the local environment, widens the gap between what is transferred and the environment into which it is to go and thus makes technology absorption more difficult, costly and uncertain.

143. This is partly because much of the aid is tied and thus must be spent on goods and services from the donor country. This influences the conception and design of investment projects as well as cost of procurement. As a result, projects frequently include components which can only be provided by the donor country or which are ultimately sourced in the donor country despite their availability locally or in another developing country at a lower cost. The scale of many aid projects adds to their complexity and, when combined with the efficiency criteria built into project design, ensures a high component of technical assistance. This is particularly true where mid-term results must be obtained within two to three years so that funds can be released for the remainder of a project. In such cases pressure is put on bringing in the managerial and technical skills needed to produce rapid results, whether they are sustainable in the long term or not.

144. Given that the need for technical assistance is largely determined by the project's design, redesigning projects to maximize the complementary nature of technical assistance could go a long way towards increasing available resources for technological acquisition, modification and diffusion. New forms of co-operation, involving small and medium-sized enterprises[76] and regions in the industrialized countries, which are currently being encouraged by the Centre for Industrial Development, set up in Brussels under the Lomé Convention, may also help to reduce the scale of aid projects to more manageable levels. Untying aid would then go one step further by increasing the efficient use of available funds through the ability to purchase goods and services from least cost suppliers. It could also help to promote the utilization of endogenous technological capabilities and strengthen interlinkages in the domestic economies between consulting and engineering services on the one hand, and R and D and the capital goods sector on the other.

B. Building a commitment to technological change

145. Increasing the flow of investible resources, however, is only part of the story. As many of the case studies discussed in the assessment reveal, participation by users in the process of technological choice and in the design and implementation of projects, plays a central role in building the kind of commitment to technological change that leads to sustainability. It is evident, moreover, from the case studies that planners and policy-makers in both donor countries and host Governments at national, regional and local levels must deliberately encourage and facilitate such a process.

146. At the national level, for example, villagers need time to decide what their needs are and to express them through a community organization. Projects thus require a preparatory period in which no physical investments are made but during which information and data are collected and analysed, options are reviewed - also taking into account the need for urgent action in areas such as health, agriculture and rural infrastructure - decisions are made, and planning and preliminary budgeting begin. For more complex projects this preparatory period can take as long as two years, and during that time funding must be made available for the necessary organizers, managers, animators, researchers, and scientific and technical personnel.

147. Foreign aid agencies can play a positive role in the development of indigenous technological capabilities provided they take the time to overcome planning routines and allow for local participation. A lack of or weak participation, on the other hand, can result, for example, in a mismatch between farmer's needs and the forms of assistance they receive, inappropriate choices of technique and difficulties in operating imported plant and equipment efficiently.

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[76] In this context, see also UNCTAD's work on small and medium-sized enterprises in the transfer of technology, i.e. **"Trends in international transfer of technology to developing countries by small and medium-sized enterprises" (TD B C.6 138), "Impact of technology transfer by foreign small and medium-sized enterprises on technological development in Kenya" (UNCTAD TT 85).** "Promotion of transfers of technology by small and medium-sized enterprises to developing countries: public policy implications and applicable instruments" (UNCTAD, TD B C.6 79).

C. Shaping the domestic environment for technology absorption and innovation: the role of policies and the strengthening of the human resource base

148. From the above it is evident that there are many positive roles that Government at all levels - municipal, district and national - can play in stimulating technology absorption and innovation. Perhaps the most important of these, however, is the goal-setting role of Government and, above all, the ability of Governments to make the adoption of a conscious effort to master technology a matter for society as a whole. This will require the design of a policy environment in which the linkage between research and production is deliberately encouraged and in which producers are induced to improve product quality, increase productivity and innovate. The success of such initiatives, however, will depend not only upon the quality of these policies, the related institutional arrangements, and the consistancy and efficiency with which they are implemented, but also on the ability to elicit support from economic and social actors. This is facilitated by a high level of user participation in the process of technological choice and change.

149. Clearly, human beings are at the centre of the transfer and development of technology in the LDCs, and the strengthening of the human resource base of these countries in dealing with the manifold issues included in technology acquisition, utilization, absorption and generation is of vital importance for the achievement of successful technology policy implementation. A number of the necessary specific skills relate to capabilities for assessing, planning and programming, for selecting and negotiating, and to procurement, to tasks required at the operational level and to an increasingly variety of organizational skills. Effective commitment to a programme for mobilizing, developing and strengthening the human resource base in the LDCs also entails a search for policies and incentives to make improved use of already existing skilled resources, i.e. an effort to incorporate into the process of technological change persons who return to their country after having migrated to more developed ones. At the root of such a programme, however, there is the basic question of the orientation and content of education in LDCs. Early school leavers tend to take any job opportunity immediately; the importance of instilling scientific and technological interests might therefore be taken into account at the primary and secondary school levels. Emphasis on early technical training has become even more important to LDCs.

150. In addition to the fundamental role of an adequate policy framework and the stress on the development of the human resource base, there are a large number of other specific areas where new policy initiatives are required to strengthen technology absorption, diffusion and innovation. First, there is a need to develop technological alternatives that will enable women, the poor and the landless to benefit from technical change rather than be displaced by it. Secondly, the state has a role to play in supporting local R and D and in stimulating and protecting, at least initially, the domestic market for locally developed technologies that have a bearing on productivity growth. Government policy was an important element, for example, in the development, production and diffusion of micro-hydro technology in Nepal. government-funded research, a network of field offices of the Agricultural Development Bank of Nepal, and protection from competing imported goods combined to bring supply and demand for technological innovation into line.[77]

151. Thirdly, to create the basis for choice and enhance the potential for flexible adjustment where agricultural commodities are under pressure from synthetic or genetically engineered products, policies are required to support the development of: (1) scanning capabilities to learn more about changes under way, assessment capabilities to gauge their potential structural impact and planning capabilities to translate the information into a strategy for adjustment to change; (2) research capabilities directed towards the improvement of local production and processing techniques so that natural products remain competitive; and (3) selective research into new techniques and how to develop and utilize them. Because resources are scarce, developing a broad range of such capabilities locally may be impossible in the short and medium term. In contrast to the earlier emphasis on a concentration of R and D resources in a single centre or institution, which was consonant with the mass production model in manufacturing, today's need for flexibility creates a parallel opening for the development of a networking model through which the educational and research programmes of different universities and institutes, at national, regional and interregional levels, can be flexibly combined. Ideally, as participants in such a network, laboratories in the least developed countries would thus be able to shift their research and training focus or direction without having to invest in the establishment of entirely new institutions or mechanisms. Net-

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[77] UNCTAD, "Technology issues in the energy sector developing countries: small-scale hydropower projects in Nepal" (UNCTAD TT 62).

working would reduce the cost of developing R and D capabilities for each participating unit, and enhance the possibilities of flexible adjustment by facilitating the combination of existing personnel from different disciplines and specializations into new research teams and securing a missing skill or set of skills through the incorporation of additional participants into the network. However, this international link may prove to be too distant, and the cost involved very high, given the weak resource position of local institutes. More direct involvement by an international organization with the capability to develop products suited to local markets could be encouraged, which could assist in providing access to the R and D and other technology organizations in the industrialized and more developed developing countries and in inducing local entities to become innovative. Obviously, as the local technology organizations in LDCs accumulate capabilities they can take over the operation of such an organization.

152. Fourthly, the challenges posed by technology to the LDCs in the 1990s particularly demand an exercise in the rethinking of related policy issues. There are many areas in which fundamental issues concerning the transfer and development of technological capabilities need to be thoroughly examined. UNCTAD can assist the LDCs in this process.[78] Much of the earlier debate on the choice of technology, for example, focused on the question of employment. Today, participation in the process of technological choice is itself a central factor in building indigenous technological capabilities and in ensuring a commitment to technological change. Technology absorption of this sort, moreover, is facilitated when imported product, process and organizational technologies are adapted to local factor and consumer markets. The lack of technological absorption that results when such a process is ignored is well documented by the case studies in the assessment. Among the factors that accounted for low and sometimes declining levels of production recorded in many manufacturing projects in the LDCs were poor maintenance, leading to lower volumes and poorer quality of output, underutilized capacity resulting from inappropriate product and process choices leading to a lack of specialization and unduly high import content (for material as well as non-material inputs such as design and management capabilities), and a series of failures in engineering (incorrect choice of machinery, poor plant layout), management (unduly high gearing ratios, unadapted management and labour control systems) or marketing (errors in the choice of market segments). These factors have had serious repercussions for the cost competitiveness of firms in the LDCs and in many instances have led to plant closures and tremendous loss of capital and employment.

153. Yet the lessons of the past still have not always been learned. Proposals to promote export manufacturing initiatives, for example, seem destined to face problems when designed to replicate existing products in conformity with what have become international standards for price, product design and quality. In so doing they tend to reproduce the need for more sophisticated production and management systems, widen the gap between the model and the market and make technology absorption more difficult. This does not negate the importance of export-oriented activities such as raw materials processing that, by using local inputs, significantly increases domestic value added and improves the gains from trade. But it does suggest that, given the special conditions prevailing in the LDCs, more attention needs to be paid to improving traditional techniques of production in terms of costs per unit, productivity per unit of factor inputs, and quantity and quality of output, and in linking these productive activities to markets including user industries (forward processing, subcontracting relationships). In many instances this will require a reallocation of resources towards the smaller, micro-enterprise sector.

154. Stressing the development of the micro-enterprise sector, however, is not meant to imply that all projects should be small-scale or based exclusively on the improvement of existing indigenous techniques. Quite the contrary, the line of argument pursued here emphasizes that variety is an important means of maximizing flexibility and permitting the recombining of the domestic resources needed for a process of continuous change. In many ways new technologies can and must complement efforts to develop the micro-enterprise sector. This is a vital component of a strategy of production based on close ties between clients and suppliers and subcontracting relationships. In micro-electronics, such technologies may also offer interesting possibilities for strengthening the skill base through what we might term 'distance learning' and for improving products and making processes more efficient through 'distance diagnosis'. But the more general application of highly automated techniques of production and management is unlikely to produce gains similar to those obtainable in the advanced industrial countries, and there is evidence to show

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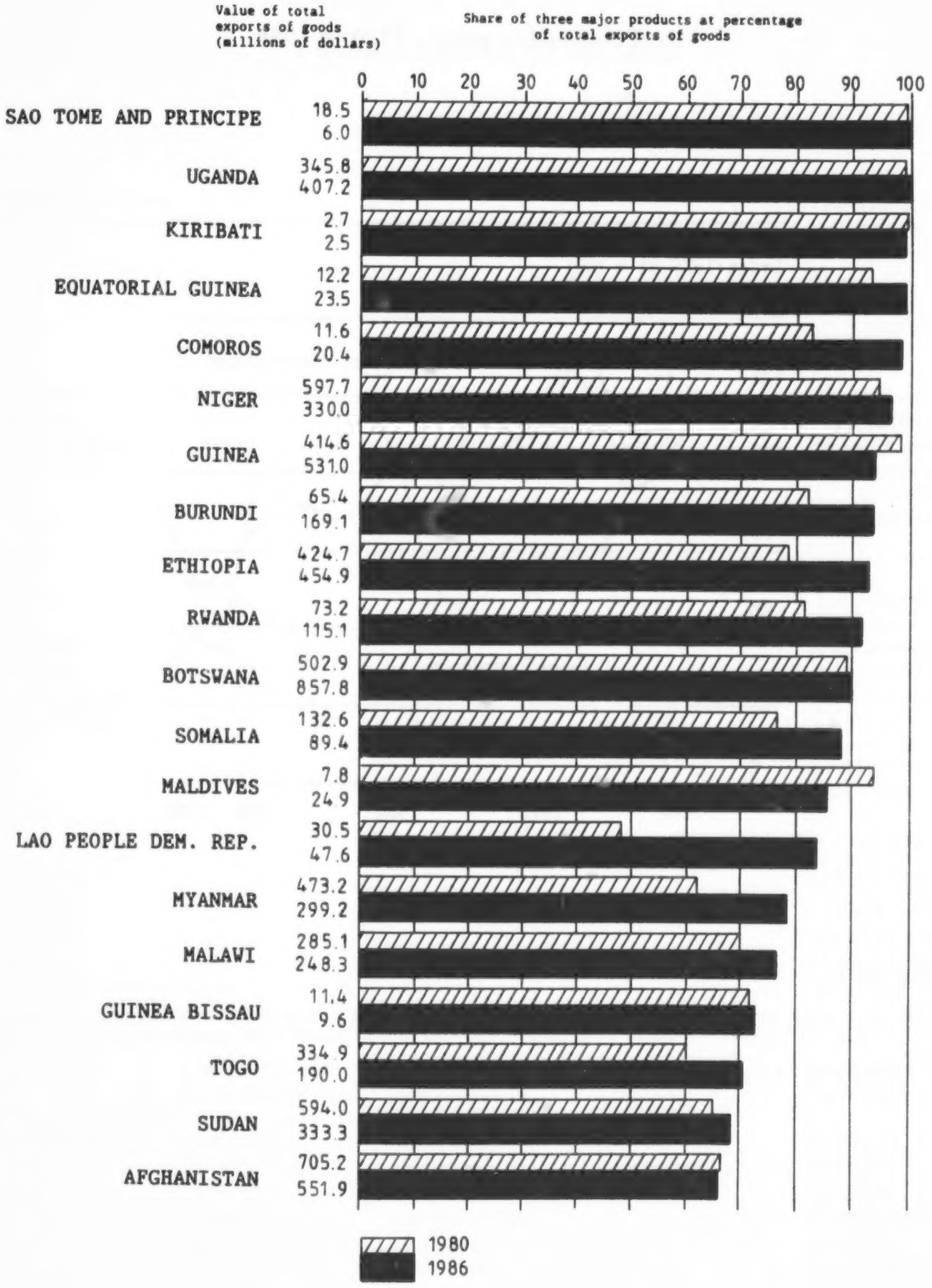
[78] UNCTAD's Advisory Service on Transfer of Technology (ASTT) has been requested by the Committee on Transfer of Technology at its seventh session to continue its activities with a view to strengthening the technological capacities of developing countries, with special emphasis on the least developed countries. For recent work of the ASTT, see **"Activities of the Advisory Service on Transfer of Technology"** (TD/B/C.6/147/Add.1), and forthcoming report for the Committee at its eight session.

that it may actually limit the possibilities for rapid technological absorption and increase costs (especially financial charges, maintenance costs, and expatriate salaries) without a corresponding increase in output or productivity under conditions existing in the LDCs today.

155. This also requires a fresh look at the question of new technologies. While there are some grounds for arguing that frontier technologies such as biotechnology or micro-electronics involve a more complex mix of skills, knowledge and productive capabilities than many established technologies, this alone does not provide the grounds for rejecting their use and even their production in the least developed countries. What appears to matter most is the selectivity with which the choice of techniques is made, and the degree of consistency with which a conscious process of building the indigenous technological capabilities required for their mastery is undertaken. In addition, the ability to assess the opportunities and constraints posed by technological change is crucial to the design of new investment programmes and rehabilitation projects in the LDCs. Clearly there is a need for a mixture of techniques in the LDCs, but the absence of sufficient indigenous engineering design, prototype development and manufacturing capabilities limits the ability of actors in the local environment to perceive opportunities for the recombination of technological capabilities and to act on that perception. The lack of assessment, selection, acquisition and negotiation skills, weak operating and organizational capabilities, and limited problem-identification and problem-solving capabilities further reduce the ability of LDCs to deal with today's changing technological and competitive environment. Building up these capabilities and learning to manage the aid process, where foreign aid continues to be a major source of funds for technical assistance and capital goods imports, are thus central elements in the broader process of development. Innovating in the organization and manner of international technical assistance is required for it to increasingly complement local capabilities being developed, and offer a broader view of technological development possibilities, encouraging LDC entities in furthering an adequate "technological culture". Strengthening the commitment to technological change, however, will also require greater participation by users - women, villagers, artisans - in the planning of technological change. In sum, there is a pressing need not only to increase resources but also to use them in a complementary way so that a national technological capacity is created and the commitment is made to sustain it.

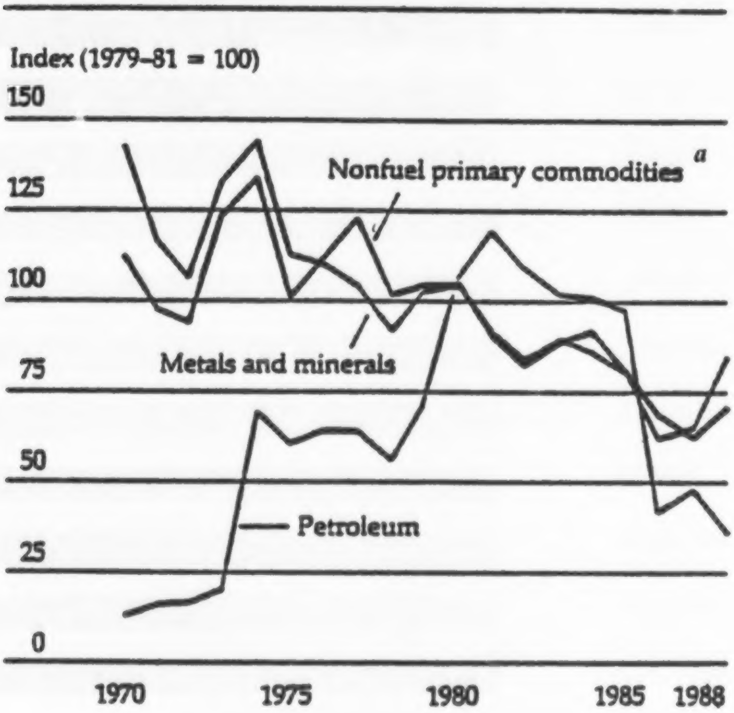
FIGURE 1
CONCENTRATION OF MERCHANDISE EXPORTS IN SELECTED LDCS:
Share of three major products, 1980 and 1986



Source: UNCTAD secretariat, based on United Nations Statistical Office, FAO, IMF and national sources.

Figure 2

Real commodity prices, 1970 to 1988



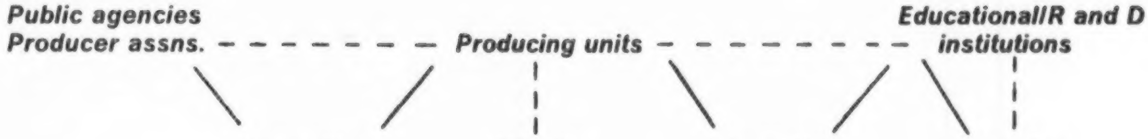
Source: IBRD, *World Development Report 1989*, p. 11.

Note: Real prices are annual average prices in dollars, deflated by the annual change in the manufacturing unit value (MUV) index, a measure of the price of industrial country exports to developing countries.

a Based on a basket of 33 commodities.

Figure 3

A matrix of technological capabilities



	Acquisition 'know-what'	Utilization 'know-how'	Absorption 'know-why'	Innovation
Product-related technological capabilities	to evaluate and asesss alternatives	quality control/ standardization	to specify in-house & commission spare parts & component manufacture	to develop new products or work with designers and R & D instit. to this effect
Process-related technological capabilities	to scan, choose and access suppliers to depackage imported technology	problem identification to source & procure spare parts and other inputs	problem solving to modify existing plant and equipment	in-house process engineering, to reproduce and redesign existing processes and create new ones linkages to indigenous engineering consultancy services and to domestic suppliers
Organizational technologies	selection and acquisition skills, e.g. bargaining, ability to arrange financing & prepare feasibility studies	to organize and carry out maintenance routines, training activities & day-to-day production activities	strategic planning capabilities marketing skills	in-house R & D capabilities ability to change decision routines & alter the organization of production

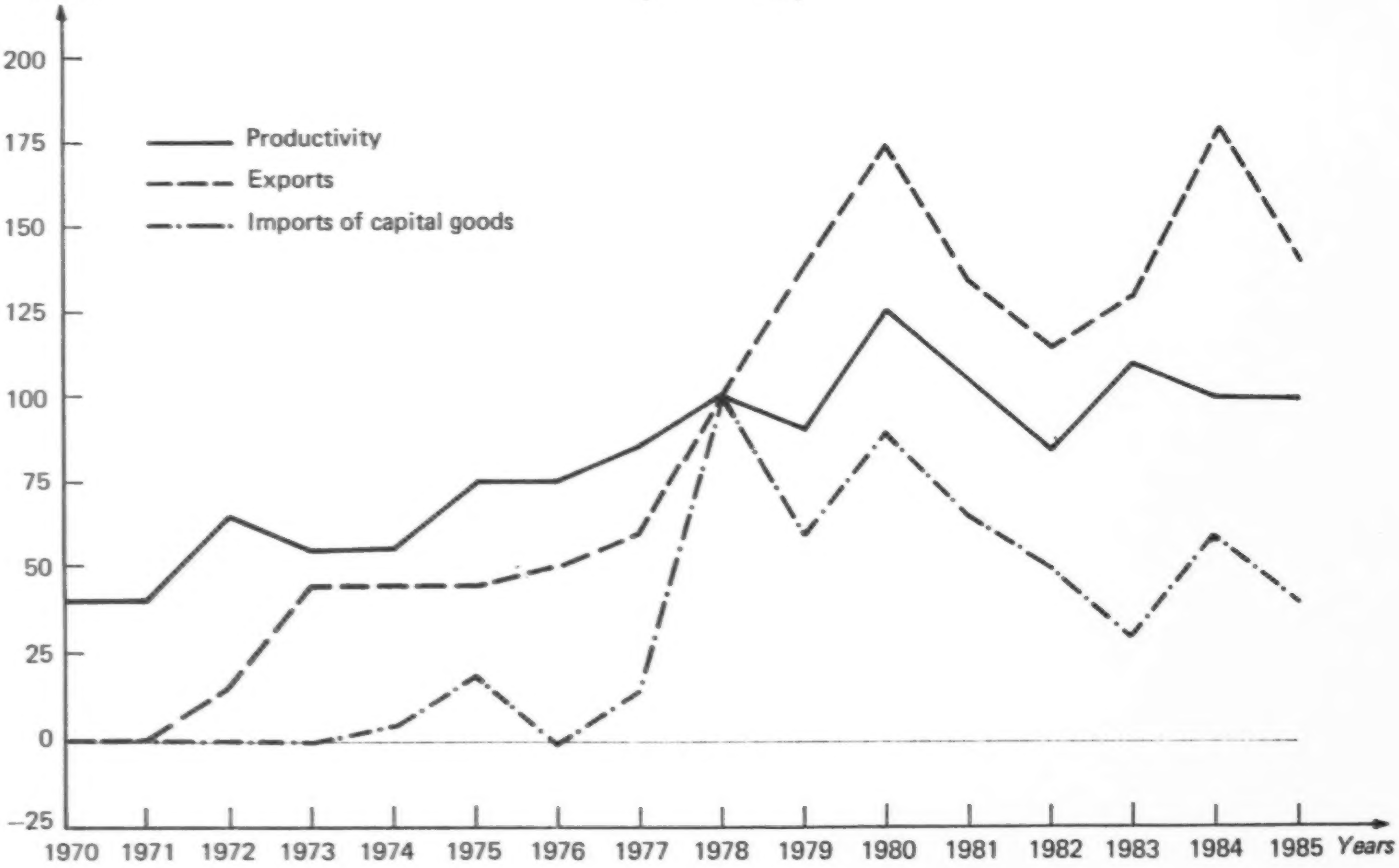
Figure 4

The case studies

Sector/ Area	Technology acquisition	Technology utilization	Technology absorption	Technology innovation
Industry	Pyrethrum extraction and refining (Rwanda)	Cement (Togo, Benin and Rwanda) Textiles (Bangladesh)		Maize milling (Tanzania)
Agriculture	Improved livestock and fruit trees (Nepal)			Tea cloning Rice (Malawi) milling (Bangladesh)
Energy				Hydro- Micro-hydro electricity (Nepal) (Tanzania)
Training and Services	Organization and tech. capacity building among urban artisans (Rwanda)			Training Engineering of seamen design (Tuvalu) (Sierra Leone) The Grameen Bank (Bangladesh)

Figure 5

BANGLADESH ISIC 321: CHANGES OF PRODUCTIVITY, CAPITAL GOODS AND EXPORTS
(1978 = 100)



Source: UNCTAD secretariat.

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